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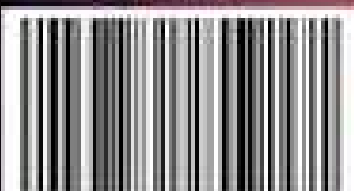
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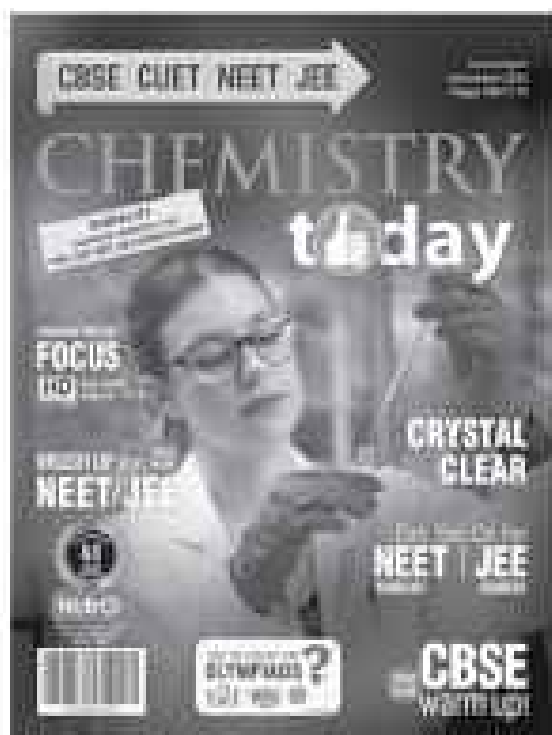
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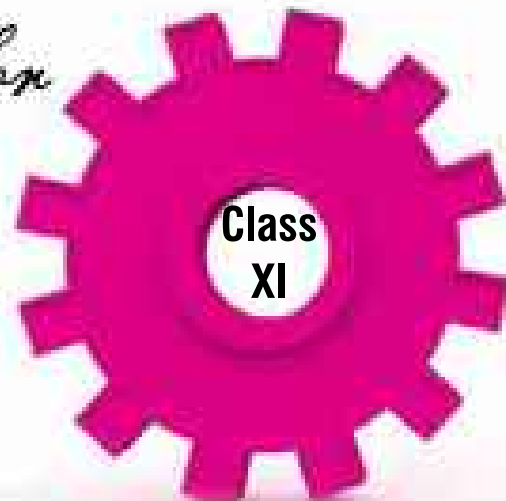
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GET SET GO for JEE



with exclusive and brainstorming MCQs

Practicing these MCQs help to strengthen your concepts and give you extra edge in your JEE preparation

1. Which statement is correct about O_2^+ ?

- (a) Paramagnetic and bond order $< O_2$
- (b) Paramagnetic and bond order $> O_2$
- (c) Diamagnetic and bond order $< O_2$
- (d) Diamagnetic and bond order $> O_2$

2. Match the correct ionisation enthalpies and electron gain enthalpies of the following elements.

Elements		$\Delta H_1, \Delta H_2, \Delta_{eg}H$	
(A)	Most reactive non-metal	(i)	419, 3051, -48
(B)	Most reactive metal	(ii)	1681, 3374, -328
(C)	Least reactive element	(iii)	738, 1451, -40
(D)	Metal forming binary halide	(iv)	2372, 5251, +48

- (a) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (i), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iii)
- (b) (A) $\rightarrow$ (i), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iv)
- (c) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (iii)
- (d) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (ii)

3. A sample of a hydrate of barium chloride weighing 61 g was heated until all the water of hydration is removed. The dried sample weighed 52 g. The formula of the hydrated salt is (atomic mass of Ba = 137 amu, Cl = 35.5 amu)

- (a) $BaCl_2 \cdot H_2O$
- (b) $BaCl_2 \cdot 2H_2O$
- (c) $BaCl_2 \cdot 3H_2O$
- (d) $BaCl_2 \cdot 4H_2O$

4. Match the column I with column II and mark the appropriate choice.

Column I		Column II	
(A)	Used as lubricant	(i)	Carbon dioxide
(B)	Oxide with three-dimensional structure	(ii)	Graphite
(C)	Used in solar cells	(iii)	Silica
(D)	Anhydride of carbonic acid	(iv)	Silicone

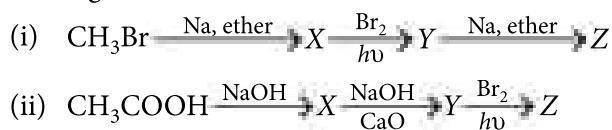
- (a) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (i)
- (b) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (ii)
- (c) (A) $\rightarrow$ (iii), (B) $\rightarrow$ (ii), (C) $\rightarrow$ (i), (D) $\rightarrow$ (iv)
- (d) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (i)

5. A piston filled with 0.04 mol of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0°C. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be

$$(R = 8.314 \text{ J/mol K}) (\ln 7.5 = 2.01)$$

- (a) $q = +208 \text{ J}, w = +208 \text{ J}$
- (b) $q = +208 \text{ J}, w = -208 \text{ J}$
- (c) $q = -208 \text{ J}, w = -208 \text{ J}$
- (d) $q = -208 \text{ J}, w = +208 \text{ J}$

6. In the given reactions:



Identify X, Y and Z.

- | | X | Y | Z |
|----------|-----------------------------------|-----------------------------------|--|
| (a) (i) | CH_4 | CH_3Br | CH_3CH_3 |
| (a) (ii) | CH_3COONa | CH_3CH_3 | $\text{CH}_3\text{CH}_2\text{Br}$ |
| (b) (i) | CH_3CH_3 | CH_4 | CH_3Br |
| (b) (ii) | CH_3COONa | CH_4 | $\text{CH}_3\text{CH}_2\text{CH}_3$ |
| (c) (i) | $\text{CH}_3\text{CH}_2\text{Br}$ | CH_3CH_3 | $\text{CH}_3\text{CH}_2\text{CH}_3$ |
| (c) (ii) | CH_3COONa | CH_4 | CH_3Br |
| (d) (i) | CH_3CH_3 | $\text{CH}_3\text{CH}_2\text{Br}$ | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ |
| (d) (ii) | CH_3COONa | CH_4 | CH_3Br |

7. Which of the following on thermal decomposition yields a basic as well as an acidic oxide?

- (a) KClO_3 (b) CaCO_3
(c) NH_4NO_3 (d) NaNO_3

8. Which one of the following statements is not true about the effect of an increase in temperature on the distribution of molecular speeds in a gas?

- (a) The most probable speed increases.
(b) The distribution becomes broader.
(c) The fraction of the molecules with the most probable speed increases.
(d) The area under the distribution curve remains the same as under the lower temperature.

9. Identify the wrong statement among the following.

- (a) Acid rain is mostly because of oxides of nitrogen and sulphur.
(b) Chlorofluorocarbons are responsible for ozone layer depletion.
(c) Greenhouse effect is responsible for global warming.
(d) Ozone layer does not permit infrared radiation from the sun to reach the earth.

10. Arrange the following solutions in the decreasing order of pOH :

- (A) 0.01 M HCl
(B) 0.01 M NaOH
(C) 0.01 M CH_3COONa
(D) 0.01 M NaCl
(a) $(A) > (D) > (C) > (B)$
(b) $(A) > (C) > (D) > (B)$
(c) $(B) > (C) > (D) > (A)$
(d) $(B) > (D) > (C) > (A)$

11. The states of hybridisation of boron and oxygen atoms in boric acid (H_3BO_3) are respectively

- (a) sp^2 and sp^2 (b) sp^2 and sp^3
(c) sp^3 and sp^2 (d) sp^3 and sp^3

12. In a reaction container, 100 g of hydrogen and 100 g of Cl_2 are mixed for the formation of HCl gas. What is the limiting reagent and how much HCl is formed in the reaction?

- (a) H_2 is limiting reagent and 36.5 g of HCl are formed.
(b) Cl_2 is limiting reagent and 102.8 g of HCl are formed.
(c) H_2 is limiting reagent and 142 g of HCl are formed.
(d) Cl_2 is limiting reagent and 73 g of HCl are formed.

NUMERICAL PROBLEMS

13. Ratio of energy of 3rd and 4th orbit of H-atom is _____. (Nearest integer)

14. 0.25 g of an organic compound on Kjeldahl's analysis gave enough ammonia to just neutralize 10 cm³ of 0.5 M H_2SO_4 . The percentage of nitrogen in the compound is _____.

15. The hardness of a water sample (in terms of equivalents of CaCO_3) containing 10^{-3} M CaSO_4 is _____. (Molar mass of $\text{CaSO}_4 = 136 \text{ g mol}^{-1}$)

SOLUTIONS

1. (b): O_2^+ has one unpaired electron and O_2 has two unpaired electrons. Thus, both are paramagnetic species and bond order of $\text{O}_2^+ = 2.5$ and $\text{O}_2 = 2$.

2. (c)

3. (b): Weight of hydrated $\text{BaCl}_2 = 61 \text{ g}$

Weight of anhydrous $\text{BaCl}_2 = 52 \text{ g}$

$\therefore$ Loss in mass = $61 - 52 = 9 \text{ g}$

Assuming $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$ as hydrate;

Mass of H_2O removed = 9 g

Moles of H_2O removed = $9/18 = 0.5$

Molecular mass of $\text{BaCl}_2 = 208$

% of H_2O in the hydrated BaCl_2

$$= \frac{9}{61} \times 100 = 14.75\% \Rightarrow 14.75 = \frac{18x}{208 + 18x} \times 100$$

On solving we get, $x = 2$

$\therefore$ The formula of the hydrated salt is $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$.

4. (d)

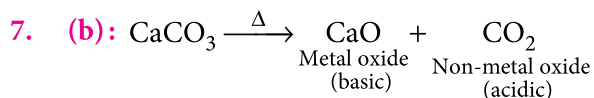
5. (b): As it absorbs heat, $q = +208 \text{ J}$

$$w_{\text{rev}} = -2.303nRT \log_{10} \left(\frac{V_2}{V_1} \right)$$

$$= -2.303 \times (0.04) \times 8.314 \times 310 \log_{10} \left(\frac{375}{50} \right)$$

$$\therefore w_{\text{rev}} = -207.76 \approx -208 \text{ J}$$

6. (d)



8. (c): Most probable speed is defined as the speed possessed by maximum number of molecules of a gas at a given temperature. According to Maxwell's distribution curves, as temperature increases, most probable speed increases and fraction of molecules possessing most probable speed decreases.

9. (d): The thick layer of ozone is called ozone blanket which is effective in absorbing harmful ultraviolet rays given out by the sun acts as a protective shield. It does not permit the ultraviolet rays from sun to reach directly to the Earth.

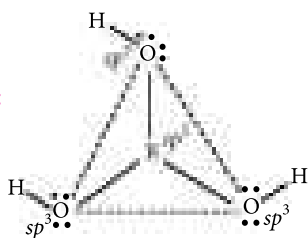
10. (a): (A) 0.01 M HCl
 $[\text{H}^+] = 10^{-2}$; $\text{pH} = -\log 10^{-2} = 2$
 $\text{pH} + \text{pOH} = 14 \therefore \text{pOH} = 12$

- (B) 0.01 M NaOH
 $[\text{OH}^-] = 10^{-2}$; $\text{pOH} = -\log 10^{-2} = 2$

- (C) $0.01 \text{ M CH}_3\text{COONa}$
 As CH_3COONa is a salt of weak acid and strong base, therefore, its $\text{pH} > 7$
 $\therefore \text{pOH} < 7$

- (D) 0.01 M NaCl
 As NaCl is a neutral salt, thus, its $\text{pH} = 7$ and $\text{pOH} = 7$. Therefore, decreasing order of pOH of given solutions is $A > D > C > B$.

11. (b):



12. (b)

13. (2): Energy of 3rd energy level = $\frac{-13.6 \times Z^2}{n^2} \text{ eV}$
- $$= \frac{-13.6 \times 1^2}{3^2} \text{ eV} = \frac{-13.6}{9} \text{ eV}$$

$$\text{Energy of 4th energy level} = \frac{-13.6 \text{ eV}}{4^2} = \frac{-13.6}{16} \text{ eV}$$

$$\text{Ratio of 3rd and 4th energy level} = \frac{E_3}{E_4}$$

$$= \frac{\frac{-13.6 \text{ eV}}{9}}{\frac{-13.6 \text{ eV}}{16}} = \frac{16}{9} = 1.77 \approx 2$$

14. (56): Percentage of N in a compound

$$= \frac{1.4 \times N_1 \times V}{W}$$

where, N_1 = Normality of the standard acid used.

Given, $0.5 \text{ M H}_2\text{SO}_4$ is used.

Normality = Molarity $\times n$

$$\text{where, } n = \frac{\text{Mol. mass}}{\text{Eq. mass}} = \frac{98}{49} = 2$$

$$\therefore \text{Normality} = 0.5 \times 2 = 1 \text{ N H}_2\text{SO}_4 = N_1$$

V = Volume of standard acid used to neutralise $\text{NH}_3 = 10 \text{ cm}^3$

W = Mass of organic compound taken = 0.25 g

$$\therefore \% \text{ of N in a compound} = \frac{1.4 \times 1 \times 10}{0.25} = 56\%$$

15. (100): 10^{-3} M means 10^{-3} moles of CaSO_4 are present in 1 L of water.

$$10^{-3} \text{ moles CaSO}_4 = \frac{\text{Mass of CaSO}_4}{\text{Molar mass of CaSO}_4}$$

Mass of $\text{CaSO}_4 = 10^{-3} \text{ mol} \times 136 \text{ g mol}^{-1}$ or 136 mg
i.e., 136 mg of CaSO_4 is present in 1 kg of water

$\therefore 10^6 \text{ g}$ of water will have 136000 mg CaSO_4

$136 \text{ g CaSO}_4 \equiv 100 \text{ g CaCO}_3$

$$136000 \text{ mg CaSO}_4 = \frac{100}{136} \times \frac{136000}{1000} = 100 \text{ g CaCO}_3$$

Thus, hardness of water = 100 ppm .

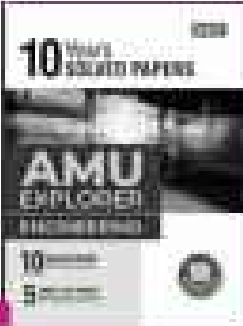


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BRUSH UP ^{for} NEET/JEE

CLASS-XI

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Unit 4 The s-Block Elements | The p-Block Elements (Group 13 and 14)

THE s-BLOCK ELEMENTS

The elements in which the last electron enters the s-orbital are called s-block elements. As s-orbital can accommodate only two electrons, hence it has two groups:

- Group 1 elements or alkali metals
- Group 2 elements or alkaline earth metals

GROUP-1 ELEMENTS

Group 1 consists of the elements: lithium, sodium, potassium, rubidium, caesium and francium.

Occurrence

Alkali metals are highly reactive and hence do not occur in the free state but are widely distributed in nature in combined state in form of halides, oxides, silicates, borates and nitrates.

Electronic Configuration

The general electronic configuration of group-1 elements is ns^1 .

Physical Properties

- **Atomic and ionic radii** : Alkali metal atoms are largest in their corresponding period in periodic table. Atomic as well as ionic size increases from Li to Fr due to the presence of an extra shell of electrons.
- **Density** : Their densities are quite low and increase from Li to Cs; however potassium is lighter than sodium (anomaly) probably due to an unusual increase in atomic size of potassium.

- **Melting and boiling points** : The melting and boiling points of alkali metals are very low because of weak intermetallic bonding. Boiling point and melting point decrease on moving down the group from Li to Cs.
- **Ionization energy** : Alkali metals have the lowest ionization energy in their corresponding period in periodic table. Ionization energy of alkali metals decreases from Li to Cs due to increase in atomic size.
- **Hydration of ions** : The solubility of alkali metal salts in water is due to the fact that the cations get hydrated by water molecules. The degree of hydration depends upon the size of the cation. Smaller the size of a cation, greater is its charge density and hence greater is its tendency to draw electrons from molecules which are thus polarized.
$$Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$$

(Relative ionic radii)
$$Li^+_{(aq)} > Na^+_{(aq)} > K^+_{(aq)} > Rb^+_{(aq)} > Cs^+_{(aq)}$$

(Relative ionic radii in water or relative degree of hydration)

Chemical Properties

All the alkali metals are highly reactive elements since they have a strong tendency to lose the single valence s-electron to form unipositive ions, and due to this reason alkali metals also act as strong reducing agents. Thus, reactivity of these elements is measured in terms of their **reducing character**.

Since the ionization enthalpies of alkali metals decrease down the group, therefore, their reducing character or

reactivity in the gaseous state increases from Li to Cs, *i.e.*, $\text{Li} < \text{Na} < \text{K} < \text{Rb} < \text{Cs}$.

However, in aqueous solution, it has been observed that the reducing character of alkali metals follows the sequence : $\text{Na} < \text{K} < \text{Rb} < \text{Cs} < \text{Li}$. In other words, Li is the strongest while sodium is the least powerful reducing agent in aqueous solution.

Reactivity towards Oxygen

When heated in excess of air, alkali metals form different types of oxides depending upon the nature of the metal, *e.g.*, Lithium when heated in oxygen forms lithium monoxide (and some lithium peroxide).



Other alkali metals, *i.e.*, K, Rb and Cs react with oxygen to form superoxides of the general formula, MO_2 where $M = \text{K}, \text{Rb}$ and Cs .

Reactivity towards water

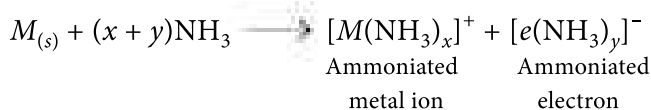
Alkali metals react with water, liberating H_2 and forming their hydroxides.



Lithium is the least reactive while the reactivity of other alkali metals towards water increases on moving down the group from Na to Cs.

Solubility in Liquid Ammonia

Alkali metals are highly soluble in liquid ammonia. Solubility of alkali metals in liquid ammonia is due to the ionisation of alkali metal atom into ammoniated metal ion and ammoniated electron.



The solution is paramagnetic and blue in colour due to the ammoniated electrons which absorb energy in visible region and impart blue colour to the solution. In concentrated solution, the blue colour changes to bronze colour and becomes diamagnetic due to pairing of electrons.

Reactivity towards Halogens

Alkali metals react vigorously with halogens to form ionic metal halides of the general formula, $M^+ X^-$.



The reactivity of alkali metals towards a particular halogen increases as we move down the group from Li

to Cs due to a decrease in the ionization enthalpy or increase in the electropositive character of the metal.

Metal	Li	Na	K	Rb	Cs
Colour	Crimson Red	Yellow	Pale violet	Red violet	Blue

General Characteristics of the Compounds of the Alkali Metals

Group-1 metal compounds are mostly ionic in nature.

Oxides and Hydroxides

All the alkali metals, their oxides, peroxides and superoxides readily dissolve in water to produce corresponding hydroxides which are strong alkali, *e.g.*,



Thus, peroxides and superoxides also act as oxidising agents since they react with H_2O forming H_2O_2 and O_2 respectively.

The basic strength of these hydroxides increases as we move down the group from Li to Cs.

Halides

Halides of alkali metals are colourless high melting crystalline solids having high negative enthalpies of formation. However, the ΔH_f° values for fluorides become less and less negative as we move down the group while for chlorides, bromides and iodides, these values become more and more negative.

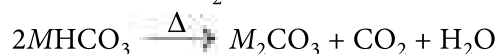
Carbonates

The carbonates ($M_2\text{CO}_3$) of alkali metals are quite stable towards heat. Li_2CO_3 , however, is considerably less stable and decomposes readily on heating. As the size of the cation increases from Na^+ to Cs^+ , the lattice energy of their corresponding oxides decrease and hence the stability of their carbonates increases from Na_2CO_3 to Cs_2CO_3 .



Bicarbonates

Being strongly basic, alkali metals also form solid bicarbonates. All the bicarbonates on gentle heating undergo decomposition to form carbonates with the evolution of CO_2 .



Diagonal Relationship of Li with Mg

- Lithium shows in anomalous behaviour due to its small size and resembles magnesium mainly due to the similarity in sizes of their atoms.
- Both Li and Mg are quite hard. They are harder and have high m.pt. than other elements in their respective groups.
- Carbonates, nitrates and hydroxides of both Li and Mg decompose on heating.
- Combine directly with N_2 :
 $6Li + N_2 \longrightarrow 2Li_3N$; $3Mg + N_2 \longrightarrow Mg_3N_2$

GROUP-2 ELEMENTS

The elements of group 2 include beryllium, magnesium, calcium, strontium, barium and radium.

Occurrence

Like alkali metals, alkaline earth metals are also highly reactive and hence do not occur in the free state but are widely distributed in nature in the combined state as silicates, carbonates, sulphates and phosphates.

Atomic Radii

The atomic and ionic radii of alkaline earth metals are fairly large though smaller than the corresponding alkali metals and these increase down the group.

Ionisation Enthalpy

The alkaline earth metals have fairly low ionization enthalpies but greater than those of the corresponding elements of group 1.

On moving down the group, ionization enthalpy values go on decreasing because of the increase in atomic size.

Hydration Enthalpy

Like alkali metal ions, the hydration enthalpies of alkaline earth metal ions decrease as the size of the metal ion increases down the group, *i.e.*, $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$

Electropositive or Metallic character

The alkaline earth metals are highly electropositive and metallic and their electropositive or metallic character increases down the group. However, they are less electropositive or metallic than the alkali metals.

Melting and Boiling Points

Due to their smaller size, the alkaline earth metals have higher melting and boiling points as compared to those of alkali metals. However, down the group, there is no regular trend in their melting and boiling points.

Flame Colouration

Metal	Calcium	Strontium	Barium	Radium
Colour	Brick red	Red	Apple green	Crimson

Chemical Properties

Action of air (Formation of oxides and peroxides)

- Alkaline earth metals react slowly with oxygen and form the corresponding oxides.
 - Oxides of group 2 elements are basic in nature. Their basic strength increases down the group:
 $BaO > SrO > CaO > MgO > BeO$
Strongly basic Strongly basic Basic Weakly basic Amphoteric

Action of water (Formation of hydroxides)

- Alkaline earth metals are less reactive with water as compared to alkali metals.
 - Order of the reactivity with water: $Ba > Sr > Ca > Mg$
 - $Be(OH)_2$ is amphoteric, but the hydroxides of Mg, Ca, Sr and Ba are basic. The basic strength increases from Mg to Ba.

Action of halogens

- All elements of group IIA can form halides of MX_2 type.
 $M + 2HX \longrightarrow MX_2 + H_2$
 $MO + 2HX \longrightarrow MX_2 + H_2O$
 $M(OH)_2 + 2HX \longrightarrow MX_2 + 2H_2O$
 - The halides of all other alkaline earth metals except Be are ionic. Their ionic character, however, increases down the group.

Diagonal Relationship of Be with Al

- Be^{2+} and Al^{3+} favour covalent bonding due to same charge/size ratio.
- Both form covalent compounds having low m.pt. and soluble in organic solvent.
- Both react with NaOH to liberate H_2 .
- Be_2C and Al_4C_3 both on reaction with water form CH_4 .

Important Compounds of Calcium

Compound	Preparation	Properties		Uses
		Physical	Chemical	
Calcium hydroxide or slaked lime [Ca(OH) ₂]	$\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$ $\text{CaCl}_2 + 2\text{NaOH} \rightarrow \text{Ca(OH)}_2 + 2\text{NaCl}$	It is a white amorphous powder which is sparingly soluble in water.	$\text{Ca(OH)}_2 \xrightarrow{\text{heat}} \text{CaO} + \text{H}_2\text{O}$ $\text{Ca(OH)}_2 \xrightarrow{\text{CO}_2} \text{CaCO}_3 \downarrow + \text{H}_2\text{O}$ $\text{Ca(OH)}_2 \xrightarrow{\text{Cl}_2} \text{CaOCl}_2 + \text{CaCl}_2 + \text{H}_2\text{O}$ Calcium hypochlorite	- In the preparation of mortar, a building material. - In white wash due to its disinfectant nature.
Calcium carbonate (CaCO ₃)	$\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$ $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + 2\text{NaCl}$	CaCO ₃ is a white fluffy powder, insoluble in water.	$\text{CaCO}_3 \xrightarrow{\text{heat}} \text{CaO} + \text{CO}_2$ $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ $\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2$	- As a building material in the form of marble and in the manufacture of quick lime. - As an antacid, mild abrasive in tooth paste, a constituent of chewing gum, and a filler in cosmetics.
Plaster of Paris or hemihydrate of calcium sulphate (CaSO ₄ · $\frac{1}{2}$ H ₂ O)	$2(\text{CaSO}_4 \cdot 2\text{H}_2\text{O}) \xrightarrow{393 \text{ K}} 2(\text{CaSO}_4) \cdot \text{H}_2\text{O} + 3\text{H}_2\text{O}$ Gypsum Plaster of Paris If heated above 393 K, anhydrous CaSO₄ is formed called dead burnt plaster.	It is a white powder and has remarkable property of setting with water.	$2(\text{CaSO}_4) \cdot \text{H}_2\text{O} \xrightarrow{\text{Setting}} \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ Orthorhombic $\downarrow \text{Hardening}$ $\text{CaSO}_4 \cdot 2\text{H}_2\text{O} \xrightarrow{\text{Monoclinic}} \text{CaSO}_4 \text{ (anhy.)}$ Dead plaster	- In surgery for setting broken or dislocated bones. - In making casts for statues, toys, surgical instruments etc.

THE *p*-BLOCK ELEMENTS (GROUP 13 AND 14)

- The elements in which the last electron enters into any of the outermost *p*-orbitals are called ***p*-block elements**. Thus, the general outer electronic configuration of the *p*-block elements is $ns^2 np^{1-6}$.
- The elements belonging to the group 13 to 18 of the long form of periodic table are *p*-block elements.

GROUP-13 ELEMENTS

- Group 13 of the periodic table contains six elements, boron (B), aluminium (Al), gallium (Ga), indium (In), thallium (Tl) and nihonium (Nh).

PHYSICAL PROPERTIES

Ionization Enthalpy ($\Delta_i H$)

The first ionization enthalpy $\Delta_i H_1$ (IE_1) values of group 13 elements are lower than the corresponding values of the alkaline earth elements of group 2.

On moving down the group from B to Al, IE_1 decrease as expected but the next member Ga has slightly higher IE_1 than Al. It again decreases in In and increases in the last element Tl.

Inert Pair Effect

It is the reluctance of the *s*- electrons of the valence shell to take part in bonding. It arises due to poor or ineffective shielding of the ns^2 electrons of the valence shell by the intervening *d*- and *f*-electrons. In group 13 elements, inert pair effect is more pronounced in Tl.

Oxidation State

B and Al show an oxidation state of +3 only while Ga, In and Tl show oxidation states of both +1 and +3.

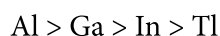
Due to inert pair effect, as we move down the group, the stability of +3 oxidation state decreases while that of +1 oxidation state increases.

Atomic and Ionic Radii

Down the group radius of group-13 elements increases due to increase in no. of shells, But radius of Ga < radius Al, because of the presence of *d*- electrons in Ga.

Reducing Character

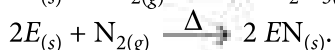
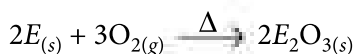
The reducing power of group 13 elements decreases down the group from aluminium to thallium as the electrode potential values for M^{3+}/M increase. Thus, the reducing power follows the trend



CHEMICAL PROPERTIES

Reactivity Towards Air

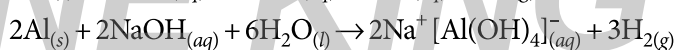
Boron is unreactive in crystalline form. Aluminium forms a very thin oxide layer on the surface which protects the metal from further attack. These metals on heating in air form oxides of the type E_2O_3 and with dinitrogen at high temperature they form nitrides.



Boron trioxide is acidic in nature while aluminium and gallium oxides are amphoteric and indium and thallium oxides are basic.

Reactivity Towards Acids and Alkalies

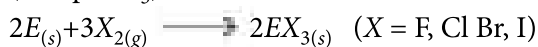
Boron does not react with acids and alkalies even at moderate temperature but aluminium dissolves in mineral acids and aqueous alkali and thus shows amphoteric character.



Concentrated nitric acid renders aluminium passive by forming protective oxide layer on the surface.

Reactivity Towards Halogens

These elements react with halogen to form trihalides (except TlI_3).



The tri-chlorides, bromides and iodides of all these elements being covalent in nature are hydrolysed in water. Species like tetrahedral $[M(OH)_4]^{-}$ and octahedral $[M(H_2O)_6]^{3+}$ (except in boron) exist in aqueous medium.

The monomeric trihalides, being electron deficient, are strong Lewis acids.

Anomalous Property of Boron

Due to the absence of *d*-orbitals the maximum covalency of B is 4. Since the *d*-orbitals are available with Al and other elements, the maximum covalency can be expected beyond 4.

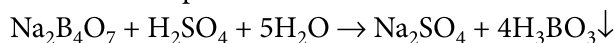
Thus, boron halides do not dimerise like other elements which can form halogen bridged molecules. Dimer of $AlCl_3$ has 3 centre -4 electron bonds.

COMPOUNDS OF BORON

Orthoboric Acid (H_3BO_3)

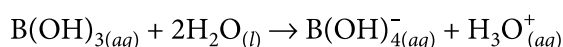
Preparation

It is precipitated by treating a concentrated solution of borax with sulphuric acid.



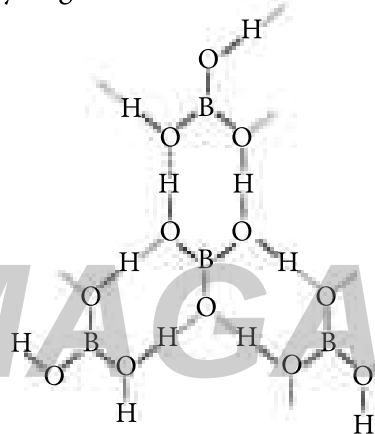
Properties

It is a weak monobasic acid.



It accepts OH^- from water, thus it functions as a Lewis acid and not as a proton donor.

It has a layered structure in which planar BO_3 units are joined by hydrogen bonds.



Uses

It is an antiseptic and its water solution is used as an eyewash.

It is also used in glass, enamel and pottery industry.

Borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$)

Preparation

It is found in nature but can also be prepared by the action of Na_2CO_3 on orthoboric acid.



Properties

- Borax is a white powder, less soluble in cold water, more soluble in hot water.
- Its aqueous solution is alkaline because of its hydrolysis to form weak acid H_3BO_3 and strong alkali NaOH .



- Action of heat**

When borax powder is heated, it first swells due to loss of water in the form of steam but at 740°C it converts into colourless transparent borax bead.



Borax-bead test: Boric anhydride reacts with certain metal salts such as, Ni^{2+} , Co^{2+} , Cr^{3+} , Cu^{2+} , Mn^{2+} etc. to form coloured metaborates. The colour of the metaborates can be used to identify the metallic ions (cations) in salts.

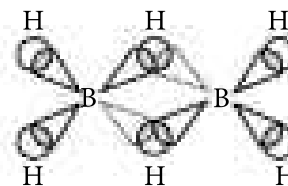


Uses

- In borax bead test
- In purifying gold
- As flux during welding of metals.

Diborane (B_2H_6)

Binary compounds of B with H are called boron hydrides or boranes.



Preparation

- $4\text{BF}_3 + 3\text{LiAlH}_4 \xrightarrow{\text{ether}} 2\text{B}_2\text{H}_6 + 3\text{LiF} + 3\text{AlF}_3$
- $2\text{BCl}_3 + 6\text{H}_2 \text{ (excess)} \xrightarrow[\text{discharge}]{\text{silent electric}} \text{B}_2\text{H}_6 + 6\text{HCl}$

Properties

- Cleavage reactions
 $\text{B}_2\text{H}_6 + 2\text{Me}_3\text{N} \rightarrow 2\text{Me}_3\text{N} \rightarrow \text{BH}_3$
 $\text{B}_2\text{H}_6 + 2\text{CO} \xrightarrow[\text{High temperature}]{200^\circ\text{C}, 20 \text{ atm}} 2\text{BH}_3\text{CO}$
- $3\text{B}_2\text{H}_6 + 6\text{NH}_3 \rightarrow 3[\text{BH}_2(\text{NH}_3)_2]^+ [\text{BH}_4]^- \xrightarrow{\text{Heat}} 2\text{B}_3\text{N}_3\text{H}_6$
In above reaction, $\text{B}_3\text{N}_3\text{H}_6$ is formed which is known as borazine (inorganic benzene).

- $n\text{B}_2\text{H}_6 \xrightarrow[\text{High temperature}]{\text{Excess NH}_3} (\text{BN})_n$
Diborane $\rightarrow$ Boron nitride
Boron nitride is known as inorganic graphite.

GROUP-14 ELEMENTS

Group 14 of the periodic table contains six elements i.e., carbon (C), silicon (Si), germanium (Ge), tin (Sn), lead (Pb) and flerovium (Fl).

PHYSICAL PROPERTIES

Atomic Radii

- The atomic radii of group 14 elements are smaller than those of corresponding elements of group 13. Because if we move from left to right in a period, effective nuclear charge increases, consequently, the size of the atom decreases.
- The atomic radii of group 14 elements increase regularly on moving down the group mainly due to increase in the number of shells.

Ionisation Energy

- The first ionization energies of the group 14 elements are higher than those of group 13 elements. This is because of their greater nuclear charge and smaller size.
- The value of ionisation energy decreases on moving down the group, though not in a regular order. The ionisation energy of group 14 elements follows the order : $C > Si > Ge > Sn < Pb$

Catenation (Tendency to Form Chains)

- Catenation is the property of elements to form long chains or rings by self-linking of their own atoms through covalent bonds.
- The tendency for catenation decreases in the order $C \gg Si > Ge \approx Sn \gg Pb$
- Carbon shows a remarkable catenation due to smaller size and high electronegativity, so that C–C bond is extremely stable.

Allotropy

- The phenomenon of existence of the same substance (element or compound) in two or more forms, in the same physical state, having different properties. Except lead, all other elements of group 14 show allotropy.

Element	Allotropic form
C	Crystalline : Graphite, diamond and fullerene Amorphous : Coal, coke and charcoal
Si	Crystalline and amorphous
Ge	Two crystalline forms
Sn	Three forms : Grey tin, white tin, rhombic tin

CHEMICAL PROPERTIES

Oxidation State

The group 14 elements have four electrons in outermost shell. The common oxidation states exhibited by these elements are + 4 and + 2. Carbon also exhibits negative oxidation states. In heavier members the tendency to show +2 oxidation state increases in the sequence $Ge < Sn < Pb$, due to inert pair effect.

Reactivity Towards Oxygen

All members when heated in oxygen form oxides. There are mainly two types of oxides.

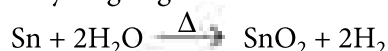
Monoxides and dioxides

Monoxides (MO)	Dioxides (MO ₂)
SiO - only exists at high temperature.	CO ₂ , SiO ₂ , and GeO ₂ - Acidic
CO - Neutral	SnO ₂ and PbO ₂ - Amphoteric
GeO - Acidic	
SnO and PbO - Amphoteric	

Oxides in higher oxidation states of elements are generally more acidic than those in lower oxidation states.

Reactivity towards water

Carbon, silicon, germanium and lead are not affected by water. Tin decomposes in steam to form dioxide and dihydrogen gas.



Reactivity towards halogen

Except carbon, all other members react directly with halogen under suitable condition to make halides. They form two types of halides : Dihalides (MX₂) and Tetrahalides (MX₄).

Dihalides (MX ₂)	Tetrahalides (MX ₄)
Heavier members Ge to Pb are able to make halides of formula MX ₂ .	All elements can form tetrahalides. However PbI ₄ does not exist.
MX ₂ is more ionic than MX ₄	Most of the MX ₄ are covalent in nature except SnF ₄ and PbF ₄ .

Stability of dihalides increase down the group while that of tetrahalides decrease down the group.

Except CCl₄, other tetrachlorides are easily hydrolysed by water because the central atom can accommodate the lone pair of electrons from oxygen atom of water molecule in *d*-orbital.

COMPOUNDS OF CARBON

Oxides of Carbon

Carbon dioxide (CO₂)

Preparation

- In the laboratory it can be prepared by the action of dilute HCl on marble chips:



- Industrially it is produced as a by-product during the manufacture of quicklime and in fermentation processes:



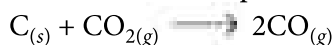
Properties

- (i) It is a colourless, odourless and heavy gas. Like all gases, it dissolves much more readily in water when the pressure is increased and this property is used in the manufacture of soda water and fizzy drinks.
- (ii) It readily reacts with alkalis forming the carbonate and, if CO₂ is in excess, the hydrogen carbonate. This is the basis of the lime-water test for CO₂ gas.

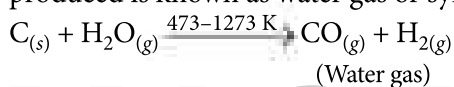
Carbon Monoxide (CO)

Preparation

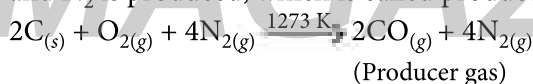
- (i) It forms together with CO₂, when carbon or carbonaceous matter is oxidized by air or oxygen. It is also produced when CO₂ is reduced by red-hot carbon; this reaction is of importance in metal extractions.



- (ii) On commercial scale, it is prepared by the passage of steam over hot coke. The mixture of CO and H₂ thus produced is known as water gas or synthesis gas.

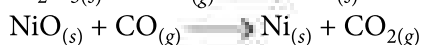


When air is used instead of steam, a mixture of CO and N₂ is produced, which is called producer gas.

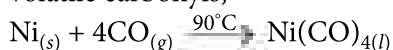


Properties

- (i) Carbon monoxide is a powerful reducing agent, so used in extraction of metals.



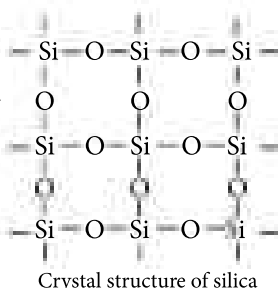
- (ii) It reacts with many transition metals, forming volatile carbonyls;



COMPOUNDS OF SILICON

Silicon Dioxide SiO₂

Silicon dioxide is a covalent, three-dimensional network solid in which each silicon atom is covalently bonded in a tetrahedral manner to four oxygen atoms. It resists the attack by halogens, dihydrogen and most of the acids and metals even at elevated temperatures. However it is attacked by HF and NaOH.



Silicones

- These are polymeric organo-silicon compounds containing Si–O–Si bonds. These have the general formula (R₂SiO)_n, where R can be –CH₃ group (in majority of cases) or –C₆H₅ group. There may be linear silicones, cyclic silicones or cross-linked silicones.

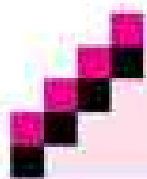
- **Properties**

- Silicones are water repellent and quite inert chemically.
- These resist oxidation, thermal decomposition and attack by organic reagents.
- Used for making water-proof papers, wools, textiles, wood, etc., after coating these articles with silicones.

Silicates

- Silicates can be considered as metal derivatives of silicic acid H₄SiO₄ or Si(OH)₄.
- Silicates are formed by heating metal oxide or metal carbonates with sand. *e.g.*,
$$nNa_2CO_3 \xrightarrow[\text{SiO}_2]{\text{Fused with sand}} Na_2(SiO_3)_n + nCO_2$$
- Silicates are classified into different types on the basis of number of oxygen atoms of SiO₄⁴⁻ shared with other tetrahedra.

Type	No. of oxygen atoms shared	Basic unit
Ortho silicates	No sharing	SiO ₄ ⁴⁻
Pyrosilicates	One oxygen atom shared	Si ₂ O ₇ ⁶⁻
Cyclic or ring silicates	Two oxygen atoms per tetrahedron shared	Si ₃ O ₉ ⁶⁻
Chain silicates	Two oxygen atoms per tetrahedron shared	(SiO ₃) _n ²⁻ or (Si ₄ O ₁₁) _n ⁶ⁿ⁻
Sheet silicates (two dimensional)	Three oxygen atoms per tetrahedron shared	(Si ₂ O ₅) _n ²⁻
Three-dimensional silicates	All four oxygen atoms shared	(SiO ₃) _n



WRAP it up!

MCQs TYPE QUESTIONS

- The set representing the correct order of first ionisation potential is
(a) $K > Na > Li$ (b) $Be > Mg > Ca$
(c) $B > C > N$ (d) $Ge > Si > C$
- Which one of the following oxides is neutral?
(a) CO (b) SnO_2 (c) ZnO (d) SiO_2
- The metallic lustre exhibited by sodium is explained by
(a) diffusion of sodium ions
(b) oscillations of loose electrons
(c) excitation of free proton
(d) existence of body centred cubic lattice.
- Which of the following statements about anhydrous aluminium chloride is correct?
(a) It exists as $AlCl_3$ molecules.
(b) It is not easily hydrolysed.
(c) It sublimes at $100^\circ C$ under vacuum.
(d) It is a strong Lewis base.
- Highly pure dilute solution of sodium in liquid ammonia
(a) contains free Na^+ ions
(b) exhibits electrical conductivity
(c) produces sodium amide
(d) produces hydrogen gas.
- Name of the structure of silicates in which three oxygen atoms of $[SiO_4]^{4-}$ are shared is
(a) pyrosilicate
(b) sheet silicate
(c) linear chain silicate
(d) three dimensional silicate.
- The correct order of thermal stability of hydroxides is
(a) $Ba(OH)_2 < Sr(OH)_2 < Ca(OH)_2 < Mg(OH)_2$
(b) $Ba(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Mg(OH)_2$
(c) $Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
(d) $Mg(OH)_2 < Sr(OH)_2 < Ca(OH)_2 < Ba(OH)_2$
- Match the items in column I with its main use listed in column II.

Column I		Column II	
(P)	Silica gel	(1)	Transistor
(Q)	Silicon	(2)	Ion-exchanger
(R)	Silicone	(3)	Drying agent
(S)	Silicate	(4)	Sealant

- (P) $\rightarrow$ (3), (Q) $\rightarrow$ (1), (R) $\rightarrow$ (4), (S) $\rightarrow$ (2)
 - (P) $\rightarrow$ (4), (Q) $\rightarrow$ (1), (R) $\rightarrow$ (2), (S) $\rightarrow$ (3)
 - (P) $\rightarrow$ (2), (Q) $\rightarrow$ (1), (R) $\rightarrow$ (4), (S) $\rightarrow$ (3)
 - (P) $\rightarrow$ (3), (Q) $\rightarrow$ (4), (R) $\rightarrow$ (1), (S) $\rightarrow$ (2)
- The set representing the correct order of ionic radius is
(a) $Li^+ > Be^{2+} > Na^+ > Mg^{2+}$
(b) $Na^+ > Li^+ > Mg^{2+} > Be^{2+}$
(c) $Li^+ > Na^+ > Mg^{2+} > Be^{2+}$
(d) $Mg^{2+} > Be^{2+} > Li^+ > Na^+$
 - Assertion :** Among the carbon allotropes, diamond is an insulator, whereas, graphite is a good conductor of electricity.
Reason : Hybridization of carbon in diamond and graphite are sp^3 and sp^2 , respectively.
(a) Both assertion and reason are true and reason is the correct explanation of the assertion.
(b) Both assertion and reason are true of but reason is not the correct explanation of the assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.
 - The substance not likely to contain $CaCO_3$ is
(a) a marble statue (b) calcined gypsum
(c) sea shells (d) dolomite.

UNSCRAMBLED WORDS

AUGUST 2023

- | | |
|-------------------|-------------------|
| 1-d- ALGAEICIDE | 2-e- FLOCCULATION |
| 3-a- FORMAZIN | 4-b- NEPHELOMETER |
| 5-c- ORTHORHOMBIC | 6-g- PHOSGENE |
| 7-f- COBALT | 8-j- OLIGOPEPTIDE |
| 9-h- TOCOPHEROL | 10-i- FRUCTOSE |

Winners : Kaushikkumar Kevadiya, Krati Trigunait

12. Which of the following exists as covalent crystals in the solid state?
 (a) Phosphorus (b) Iodine
 (c) Silicon (d) Sulphur
13. A metal M readily forms its sulphate MSO_4 which is water-soluble. It forms its oxide MO which becomes inert on heating. It forms an insoluble hydroxide $M(OH)_2$ which is soluble in $NaOH$ solution. Then M is
 (a) Mg (b) Ba (c) Ca (d) Be.
14. Boron cannot form which one of the following anions?
 (a) BF_6^{3-} (b) BH_4^-
 (c) $B(OH)_4^-$ (d) BO_2^-
15. Beryllium chloride has a linear structure in the solid state but in the vapour phase it tends to form a chlorine-bridge dimer. This is due to
 (a) its small size
 (b) its electron deficient nature
 (c) its high ionisation enthalpy
 (d) its high lattice energy.
16. Among the following substituted silanes the one which will give rise to cross linked silicone polymer on hydrolysis is
 (a) R_3SiCl (b) R_4Si
 (c) $RSiCl_3$ (d) R_2SiCl_2
17. Which of the following alkaline earth metal sulphates has highest solubility in water?
 (a) $BaSO_4$ (b) $SrSO_4$
 (c) $CaSO_4$ (d) $BeSO_4$
18. The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence
 (a) $PbX_2 \ll SnX_2 \ll GeX_2 \ll SiX_2$
 (b) $GeX_2 \ll SiX_2 \ll SnX_2 \ll PbX_2$
 (c) $SiX_2 \ll GeX_2 \ll PbX_2 \ll SnX_2$
 (d) $SiX_2 \ll GeX_2 \ll SnX_2 \ll PbX_2$
19. Which one of the following statements is correct for alkaline earth metals?
 (a) They are diatomic and form ions of the type M^{2-} .
 (b) They are highly electronegative elements.
 (c) They are monoatomic and form ions of the type M^+ .
 (d) They are monoatomic and form ions of the type M^{2+} .
20. The structure of diborane (B_2H_6) contains
 (a) four $2c-2e^-$ bonds and two $3c-2e^-$ bonds
 (b) two $2c-2e^-$ bonds and four $3c-2e^-$ bonds
 (c) two $2c-2e^-$ bonds and two $3c-3e^-$ bonds
 (d) four $2c-2e^-$ bonds and four $3c-2e^-$ bonds.

NUMERICAL VALUE TYPE QUESTIONS

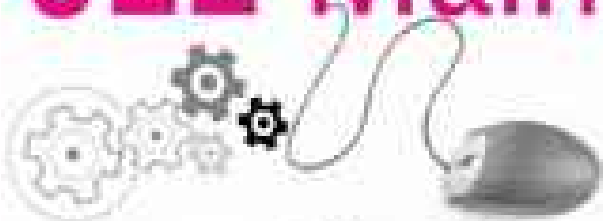
21. Among the following, number of metal/s which can be used as electrodes in the photoelectric cell is _____.
 Li, Na, Rb, Cs
22. Three moles of B_2H_6 are completely reacted with methanol. The number of moles of boron containing product is _____.
23. In the given reaction, $Na_2CO_3 \cdot 10H_2O \xrightarrow{375\text{ K}} X$.
 Number of water molecules in X is _____.
24. The value of n in the molecular formula $Be_nAl_2Si_6O_{18}$ is _____.
25. BeO reacts with HF in presence of ammonia to give (A) which on thermal decomposition produces (B) and ammonium fluoride. Oxidation state of Be in (A) is _____.



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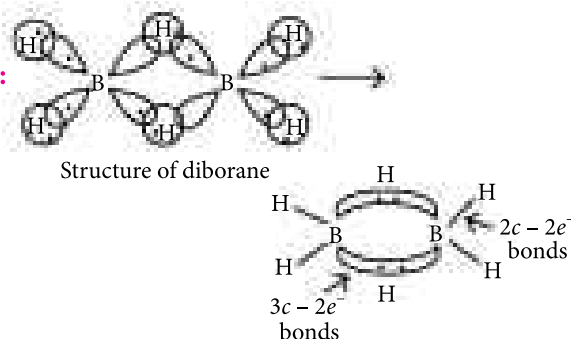
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1. (b): As we move from top to bottom of the group the atomic size increases and so the first ionisation energy decreases. Thus, the order is $\text{Be} > \text{Mg} > \text{Ca}$.
2. (a): CO is a neutral oxide.
3. (b): The metallic lustre of sodium is due to oscillations of loose electrons.
4. (c): AlCl_3 exists as Al_2Cl_6 (i.e., a dimer). Due to the presence of incomplete octet, Al has a tendency to gain electrons. Hence, AlCl_3 acts as a Lewis acid. AlCl_3 undergoes hydrolysis easily and forms $\text{Al}(\text{OH})_3$.
$$\text{AlCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + 3\text{HCl}$$
5. (b): Due to the presence of ammoniated electrons and ammoniated sodium ions the solution conducts electricity.
6. (b)
7. (c)
8. (a): Silica gel absorbs moisture thus, acts as drying agent. Silicon being a semiconductor is used in transistors. Silicone is a sealant while silicates including zeolites are ion-exchangers.
9. (b)
10. (b): Diamond is a bad conductor of electricity because of the non-availability of free electrons while graphite is a good conductor of electricity due to the fourth valence electron of each carbon which is free to move.
11. (b)
12. (c)
13. (d): Be forms water soluble BeSO_4 , water insoluble $\text{Be}(\text{OH})_2$ and BeO . $\text{Be}(\text{OH})_2$ is soluble in NaOH giving sodium beryllate Na_2BeO_2 .
14. (a): Due to non-availability of d -orbitals, boron is unable to expand its octet. Therefore, the maximum covalency of boron cannot exceed 4.
15. (b)
16. (c): RSiCl_3 on hydrolysis gives a cross linked silicone.
17. (d)
18. (d): Due to the inert pair effect (the reluctance of ns^2 electrons of outermost shell to participate in bonding) the stability of M^{2+} ions (of group IV elements) increases as we go down the group.
19. (d): Alkaline earth metals are monoatomic and form divalent cations M^{2+} .



- 21. (1):** Cs is used in photoelectric cell due to its very low ionization enthalpy.
- 22. (6):** $[B_2H_6 + 6CH_3OH \rightarrow 2B(OCH_3)_3 + 6H_2] \times 3$
 $3B_2H_6 + 18CH_3OH \rightarrow 6B(OCH_3)_3 + 18H_2$
Thus, number of moles of boron containing product formed by reacting 3 moles of B_2H_6 completely with methanol is 6.
- 23. (1):** $Na_2CO_3 \cdot 10H_2O \xrightarrow{375\text{ K}} Na_2CO_3 \cdot H_2O$
X
- 24. (3):** $Be_nAl_2Si_6O_{18}$: It is Beryl, with formula $Be_3Al_2Si_6O_{18}$, where, $n = 3$.
- 25. (2):** $BeO + 2NH_3 + 4HF \rightarrow (NH_4)_2[BeF_4]$
(A)
 $(NH_4)_2[BeF_4] \xrightarrow{\Delta} BeF_2 + 2NH_4F$
(B)
- Oxidation state of Be in (A) is +2.

ANSWERS AUGUST 2023

The 3 sets of trio are (LIC, ICL, CIL), (NTA, NAT, TAN), (SAL, ALS, LAS)

METALLIC

MICROPARTICLES

PENICILLIN

DECANTATION

DISPROPORTIONATION

BUTANE

SALICYLIC ACID

MINERALS

LASER

Winners : Kaushikkumar Kevadiya, Nikita Rana



CBSE

warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exams as per the latest pattern
and rationalised syllabus by CBSE for the academic session 2023-24.

Series-5

Equilibrium

Time Allowed : 3 hours
Maximum Marks : 70

General Instructions

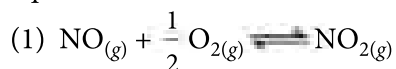
Read the following instructions carefully.

- There are 33 questions in this question paper with internal choice.
- SECTION-A consists of 16 multiple-choice questions carrying 1 mark each.
- SECTION-B consists of 5 short answer questions carrying 2 marks each.
- SECTION-C consists of 7 short answer questions carrying 3 marks each.
- SECTION-D consists of 2 case-based questions carrying 4 marks each.
- SECTION-E consists of 3 long answer questions carrying 5 marks each.
- All questions are compulsory.
- Use of log tables and calculators is not allowed.

SECTION-A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. Equilibrium constants K_1 and K_2 for the following equilibria,



are related as :

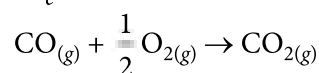
(a) $K_1 = \sqrt{K_2}$ (b) $K_2 = \frac{1}{K_1}$

(c) $K_1 = 2K_2$ (d) $K_2 = \frac{1}{K_1^2}$

2. The unit of equilibrium constant for the reaction $2\text{NO}_{2(g)} \rightleftharpoons \text{N}_2\text{O}_{4(g)}$ is

- (a) mol L^{-1} (b) L mol^{-1}
(c) $\text{mol}^{-1} \text{L}^{-1}$ (d) Equilibrium constant is unitless.

3. $\frac{K_p}{K_c}$ for following reaction will be



- (a) RT (b) $\frac{1}{RT}$ (c) $\frac{1}{\sqrt{RT}}$ (d) $\frac{RT}{2}$

4. For the decomposition reaction of lime stone, the correct expression for equilibrium constant, K_p is

(a) $K_p = \frac{P_{\text{CaO}} \cdot P_{\text{CO}_2}}{P_{\text{CaCO}_3}}$ (b) $K_p = \frac{[\text{CaO}][\text{CO}_2]}{[\text{CaCO}_3]}$

(c) $K_p = \frac{P_{\text{CaO}} + P_{\text{CO}_2}}{P_{\text{CaCO}_3}}$ (d) $K_p = P_{\text{CO}_2}$

5. The equilibrium constant, K_c for the reaction

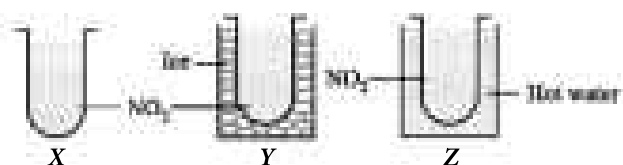
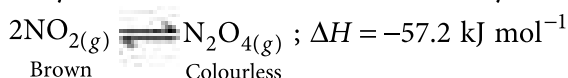


$E^\circ_{\text{cell}} = 0.46 \text{ V}$ is

- (a) antilog 15.6 (b) antilog 2.5
(c) antilog 1.5 (d) antilog 12.2

6. For the reaction, $\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$ partial pressure of CO_2 at 1000 K is 0.003 atm. Calculate the value of ΔG ($\Delta G^\circ = 27.2$ kcal).
- (a) 12.6 kcal (b) 15.6 kcal
(c) 13.4 kcal (d) 14.2 kcal

7. In an experiment, NO_2 gas is prepared and taken into 3 test tubes X, Y and Z. NO_2 gas which is brown in colour dimerises into N_2O_4 which is colourless. Test tube X is kept at room temperature, Y is kept in ice and Z is kept in hot water. What colour changes will you observe in the test tubes and why?



- (a) In test tube X, brown colour intensifies since backward reaction is favoured at low temperature.
- (b) In test tube Y, brown colour intensifies since backward reaction takes place at room temperature.
- (c) In test tube Z, brown colour intensifies since high temperature favours the backward reaction.
- (d) Brown colour of test tubes X, Y and Z remains same since there is no effect of change in temperature on the reaction.
8. For the reversible reaction,
 $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)} + \text{heat}$
 The equilibrium shifts in forward direction
- (a) by increasing the concentration of $\text{NH}_{3(g)}$
 (b) by decreasing the pressure
 (c) by decreasing the concentrations of $\text{N}_{2(g)}$ and $\text{H}_{2(g)}$
 (d) by increasing pressure and decreasing temperature.
9. Conjugate base of H_2PO_4^- is
- (a) HPO_4^- (b) HPO_4^{2-}
 (c) H_3PO_4 (d) PO_4^{3-}
10. Which of the following pairs of substances cannot exist together in solution?
- (a) $\text{Na}_2\text{CO}_3 + \text{NaOH}$ (b) $\text{NaHCO}_3 + \text{Na}_2\text{CO}_3$
 (c) $\text{NaHCO}_3 + \text{NaOH}$ (d) $\text{NaOH} + \text{NaCl}$

11. Water is well known amphiprotic solvent. In which chemical reaction water is behaving as a base?
- (a) $\text{H}_2\text{SO}_4 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{HSO}_4^-$
 (b) $\text{H}_2\text{O} + \text{NH}_2^- \rightarrow \text{NH}_3 + \text{OH}^-$
 (c) $\text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{NH}_4^+ + \text{OH}^-$
 (d) All of these

12. What will be the value of $[\text{OH}^-]^2$ in the 0.1 M solution of ammonium hydroxide having $K_b = 1.8 \times 10^{-5}$?
- (a) 1.8×10^{-7} (b) 1.8×10^{-6}
 (c) 1.8×10^{-4} (d) 1.8×10^{-3}

13. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : When ice and water are kept in a perfectly insulated thermos flask at 273 K and the atmospheric pressure, there is no change in mass of ice and water.

Reason (R) : The system is in static equilibrium.

Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
 (b) Both A and R are true but R is not the correct explanation of A.
 (c) A is true but R is false.
 (d) A is false but R is true.
14. Given below are two statements labelled as Assertion (A) and Reason (R).
- Assertion (A) :** In the dissociation of PCl_5 at constant pressure and temperature, addition of helium at equilibrium increases the dissociation of PCl_5 .
- Reason (R) :** Helium reacts with Cl_2 and hence shifts the equilibrium in forward direction.
- Select the most appropriate answer from the options given below :
- (a) Both A and R are true and R is the correct explanation of A.
 (b) Both A and R are true but R is not the correct explanation of A.
 (c) A is true but R is false.
 (d) A is false but R is true.

15. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : Higher order ionization constants (K_{a2}, K_{a3}) are smaller than the lower order ionization constant (K_{a1}) of polyprotic acid.

Reason (R) : Polyprotic acid solutions contain a mixture of acids.

Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

16. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : The strength of haloacids increases in the order $\text{HI} < \text{HBr} < \text{HCl} < \text{HF}$.

Reason (R) : Strength of acid HA depends only on the electronegativity difference between H and A. Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

SECTION-B

This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

17. The following concentrations were obtained for the formation of NH_3 from N_2 and H_2 at equilibrium at 500 K. Calculate the equilibrium constant.
 $[\text{N}_2] = 1.5 \times 10^{-2} \text{ M}$; $[\text{H}_2] = 3 \times 10^{-2} \text{ M}$;
 $[\text{NH}_3] = 1.2 \times 10^{-2} \text{ M}$.
18. For the reaction,
 $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$; $K_p = 51$
 Find the value of K_p for the reaction,
 $2\text{NH}_{3(g)} \rightleftharpoons \text{N}_{2(g)} + 3\text{H}_{2(g)}$
19. A vessel at 1000 K contains CO_2 with a pressure of 0.5 atm. Some of the CO_2 is converted into CO on addition of graphite. Calculate the value of K_p , if total pressure at equilibrium is 0.8 atm.
20. Write the conjugate acids for the following Bronsted bases :
 (i) NH_2^- (ii) HCOO^- (iii) OH^- (iv) HSO_4^-

OR

- (a) Define Arrhenius acid and base.
- (b) Write the conjugate acid of NH_3 .

21. Calculate the solubility of A_2X_3 in pure water, assuming that neither kind of ion reacts with water. The solubility product of A_2X_3 , $K_{sp} = 1.1 \times 10^{-23}$.

SECTION-C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

22. Reaction between N_2 and O_2 takes place as follows :
 $2\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{N}_2\text{O}_{(g)}$
 If a mixture of 0.482 mol of N_2 and 0.933 mol of O_2 is placed in a 10 L reaction vessel and allowed to form N_2O at a temperature for which $K_c = 2.0 \times 10^{-37}$, determine the composition of equilibrium mixture.
23. A mixture of SO_3 , SO_2 and O_2 gases is maintained at equilibrium in 10 L flask at a temperature at which K_c for the reaction $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$ is $100 \text{ mol}^{-1} \text{ L}$. At equilibrium,
 (a) if number of moles of SO_3 and SO_2 in the flask are same, how many moles of O_2 are present?
 (b) if number of moles of SO_3 in the flask is twice the number of moles of SO_2 , how many moles of O_2 are present?
24. The K_p value for the reaction, $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$ at 460°C is 49. If the initial pressure of H_2 and I_2 is 0.5 atm respectively, determine the partial pressure of each gas at equilibrium.
25. Nicotinic acid ($K_a = 1.4 \times 10^{-4}$) is represented by the formula HNic . Calculate its percentage dissociation in a solution which contains 0.10 mole of nicotinic acid per 2.0 litre of solution.
26. What is the relative acidic strength of benzoic acid and phenol if dissociation constant at 298 K for benzoic acid and phenol are 6.5×10^{-5} and 1.3×10^{-10} respectively?
27. Calculate the pH of a 10^{-6} M HCl solution if 1 mL of it is diluted to 100 mL. ($K_w = 1 \times 10^{-14}$)
28. The solubility product of $\text{Al}(\text{OH})_3$ is 2.7×10^{-11} . Calculate its solubility in g L^{-1} and also find out the pH of this solution. (Atomic mass of Al = 27 u)

OR

The values of K_{sp} of two sparingly soluble salts $\text{Ni}(\text{OH})_2$ and AgCN are 2.0×10^{-15} and 6×10^{-17} respectively. Which salt is more soluble? Explain.

SECTION-D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

29. Strength of acid is measured in terms of H^+ produced whereas strength of base is measured in terms of OH^- produced. $HA + \text{Water} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$

$$K_a = \frac{[H^+][A^-]}{[HA]} \text{ or } K_a \propto [H^+]$$

where, K_a is the dissociation constant of acid HA. Similarly for a base, $K_b \propto [OH^-]$ where K_b is the dissociation constant of a base BOH.

It means greater the value of dissociation constant (K_a or K_b), greater is the amount of H^+ or OH^- produced, and stronger is the acid or base respectively.

pH is a convenient method to represent hydrogen ion concentration. pH of a solution is defined as the negative logarithm of hydrogen ion concentration.

$$pH = -\log [H^+] \text{ or } pH = -\log [H_3O^+]$$

Answer the following questions :

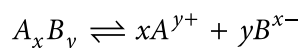
- (a) The concentration of hydrogen ion in a sample of soft drink is 4×10^{-3} M. Calculate its pH.

OR

Calculate the H_3O^+ ion concentration of a water sample having pH = 6.58.

- (b) K_a for CH_3COOH is 1.8×10^{-5} and K_b for NH_4OH is 1.8×10^{-5} . Calculate the pH of ammonium acetate.
- (c) Calculate the number of H^+ ions present in 250 mL of lemon juice with pH = 3.

30. Solubility product of a sparingly soluble salt at a given temperature is defined as the product of molar concentration of its ions in a saturated solution, with each concentration term raised to the power equal to number of ions present in the chemical equation representing the equilibrium of dissociation of one molecule of the salt. It is represented as K_{sp} .



$$\text{Solubility product } (K_{sp}) = [A^{y+}]^x [B^{x-}]^y$$

Answer the following questions :

- (a) How can the solubility (s) of CaF_2 be given in terms of its solubility product?

- (b) Calculate the solubility if the solubility product of lead iodide (PbI_2) is 3.2×10^{-8} .
- (c) The solubility of $Pb(OH)_2$ in water is 6.7×10^{-6} M. Calculate the solubility of $Pb(OH)_2$ in a buffer solution of pH = 8.

OR

In 1 L saturated solution of AgCl [$K_{sp} = 1.6 \times 10^{-10}$], 0.1 mol of CuCl [$K_{sp} = 1.0 \times 10^{-6}$] is added. Find out the resultant concentration of Ag^+ in the solution.

SECTION-E

The following questions are long answer type and carry 5 marks each. All questions have an internal choice.

31. Attempt any five of the following :

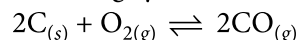
- (a) When sulphur in the form of S_8 is heated at 900 K, the initial pressure of 1 atm falls by 29% at equilibrium. This is because of conversion of S_8 to S_2 . Calculate the equilibrium constant for the reaction.

- (b) 0.4 mole of PCl_5 , 0.2 mole of PCl_3 and 0.6 mole of Cl_2 taken in a 1 L flask, reach equilibrium according to the following reaction.



If equilibrium constant for the above reaction is 0.2, then predict the direction in which reaction proceeds.

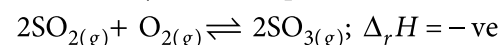
- (c) Define Le-Chatelier's principle.
- (d) What is the effect of reducing volume on the following system?



- (e) For an exothermic reaction, what happens to the equilibrium constant if the temperature is increased?

- (f) Hydrolysis of sucrose give,
 $\text{Sucrose} + H_2O \rightleftharpoons \text{Glucose} + \text{Fructose}$
 Equilibrium constant K_c for the reaction is 2×10^{13} at 300 K. Calculate ΔG° at 300 K.

- (g) Predict the favourable condition to get the maximum yield of the products in the reaction.



32. (i) The vapour density of N_2O_4 at a certain temperature is 30. Calculate the percentage dissociation of N_2O_4 at this temperature.
- (ii) 0.15 mole of CO taken in 2.5 L flask is maintained at 750 K along with a catalyst so that the following reaction can take place.



Hydrogen is introduced until the total pressure of the system is 8.5 atm at equilibrium and 0.08 mole of methanol is formed. Calculate K_c for the above equilibrium.

OR

- (i) (a) Which measurable property becomes constant in the following equilibrium at constant temperature?
 Water $\rightleftharpoons$ Water vapour
 (b) Give one example of everyday life, where gas $\rightleftharpoons$ solution equilibrium is observed.
 (ii) A process $A \rightleftharpoons B$, is in equilibrium at temperature 298 K. How much % in amount of B can be increased by adding catalyst?
 (iii) What is meant by the statement 'equilibrium is dynamic in nature'?
 (iv) Calculate the ionization constant of formic acid if its 0.01 M solution is only 14.5 % ionized.
 (v) How much should the H^+ concentration of a solution be changed to raise the pH by 2?
33. (i) If the equilibrium constant for the reaction, $2AB \rightleftharpoons A_2 + B_2$ is 49, what is the value of equilibrium constant for $AB \rightleftharpoons \frac{1}{2}A_2 + \frac{1}{2}B_2$?

- (ii) Write the equilibrium constant expressions for the following reactions:



- (iii) What is the relation between K_p and K_c for the given reaction?



OR

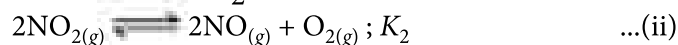
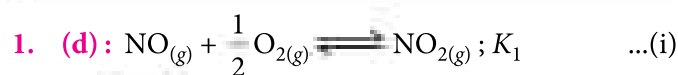
- (i) A sample of pure PCl_5 was introduced into an evacuated vessel at 473 K. After equilibrium was attained, concentration of PCl_5 was found to be $0.5 \times 10^{-1} \text{ mol L}^{-1}$. If value of K_c is 8.3×10^{-3} , what are the concentrations of PCl_3 and Cl_2 at equilibrium?

- (ii) At a certain temperature equilibrium constant (K_c) is 16 for the reaction



If we take one mole of each of all the four gases in a one litre container, what would be the equilibrium concentrations of NO and NO_2 ?

SOLUTIONS



Thus $K_2 = \frac{1}{K_1^2}$

2. (b)

3. (c) : $\Delta n_g = n_p - n_r = 1 - 3/2$

$\Delta n_g = \frac{-1}{2}$. Hence $K_p = K_c(RT)^{-1/2}$

$\frac{K_p}{K_c} = \frac{1}{(RT)^{1/2}} = \frac{1}{\sqrt{RT}}$

4. (d) 5. (a)



$K_p = p_{\text{CO}_2} = 0.003 \text{ atm}$

$\Delta G = \Delta G^\circ + 2.303RT \log K_p$
 $= 27.2 \times 1000 + 2.303 \times 2 \times 1000 \times \log 0.003 = 15.6 \text{ kcal}$

7. (c) 8. (d)



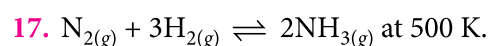
10. (c) 11. (a) 12. (b)

13. (c) : The system is in dynamic equilibrium.

14. (c) : Helium is an inert gas and hence does not react with Cl_2 . However to keep the pressure constant on addition of helium, volume of the system will increase which will favour forward reaction.

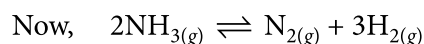
15. (b)

16. (d) : The correct order of acidic strength is $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$.



$K_c = \frac{[\text{NH}_{3(g)}]^2}{[\text{N}_{2(g)}][\text{H}_{2(g)}]^3} = \frac{(1.2 \times 10^{-2})^2}{(1.5 \times 10^{-2})(3 \times 10^{-2})^3}$
 $= \frac{1.44 \times 10^{-4}}{40.5 \times 10^{-8}} = 3.55 \times 10^2$

18. $K_p = \frac{(p_{\text{NH}_3})^2}{(p_{\text{N}_2})(p_{\text{H}_2})^3} = 51$



$K'_p = \frac{(p_{\text{N}_2})(p_{\text{H}_2})^3}{(p_{\text{NH}_3})^2} = \frac{1}{K_p} = \frac{1}{51} = 0.02$



Pressure before reaction : 0.5 atm 0
 Pressure at equilibrium : (0.5 - p) atm 2p atm

Total pressure = $0.5 - p + 2p \Rightarrow 0.8 = 0.5 - p + 2p$
 $\therefore p = 0.3 \text{ atm}$

$$\text{Hence, } K_p = \frac{(p_{\text{CO}})^2}{p_{\text{CO}_2}} = \frac{(2 \times 0.3)^2}{(0.5 - 0.3)} = 1.8 \text{ atm}$$

20. (i) NH_3 (ii) HCOOH (iii) H_2O (iv) H_2SO_4

OR

(a) Arrhenius concept defines an acid as a substance which furnishes hydrogen ions in aqueous solution and base as a substance which furnishes hydroxyl ions.

(b) NH_4^+

21. $\text{A}_2\text{X}_3 \rightarrow 2\text{A}^{3+} + 3\text{X}^{2-}$

$$K_{sp} = [\text{A}^{3+}]^2 [\text{X}^{2-}]^3 = 1.1 \times 10^{-23}$$

If s = solubility of A_2X_3 , then $[\text{A}^{3+}] = 2s$; $[\text{X}^{2-}] = 3s$

$$\text{Therefore, } K_{sp} = (2s)^2 (3s)^3 = 108s^5 = 1.1 \times 10^{-23}$$

$$\text{Thus, } s^5 = 1 \times 10^{-25}$$

$$\therefore s = 1.0 \times 10^{-5} \text{ mol/L}$$

22. $2\text{N}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{N}_2\text{O}_{(g)}$

Initial moles : 0.482 0.933 0

Moles at eqm. : $(0.482 - x)$ $(0.933 - x/2)$ x

Molar conc. : $\frac{0.482 - x}{10}$ $\frac{0.933 - (x/2)}{10}$ $\frac{x}{10}$

As $K_c = 2.0 \times 10^{-37}$ is very small, this means that the amount of N_2 and O_2 reacted (x) is very small. Hence, at equilibrium, we have

$$[\text{N}_2] = 0.0482 \text{ mol L}^{-1}, [\text{O}_2] = 0.0933 \text{ mol L}^{-1},$$

$$[\text{N}_2\text{O}] = 0.1x \text{ mol L}^{-1}$$

$$\therefore K_c = \frac{(0.1x)^2}{(0.0482)^2 (0.0933)} = 2.0 \times 10^{-37} \text{ (given)}$$

On solving this we get, $x \approx 6.6 \times 10^{-20}$

$$\therefore [\text{N}_2\text{O}] = 0.1x = 6.6 \times 10^{-21} \text{ mol L}^{-1}$$

23. $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} = 100 \text{ (given)}$$

(a) It is given that $[\text{SO}_3] = [\text{SO}_2]$ then $\frac{1}{[\text{O}_2]} = 100$

$$\text{or } [\text{O}_2] = \frac{1}{100} \text{ mol L}^{-1}$$

$$\text{O}_2 \text{ present in } 10 \text{ L} = \frac{1}{100} \times 10 = 0.1 \text{ mol}$$

(b) It is given that $[\text{SO}_3] = 2[\text{SO}_2] \Rightarrow \frac{[\text{SO}_3]}{[\text{SO}_2]} = 2$

$$\left(\frac{[\text{SO}_3]}{[\text{SO}_2]} \right)^2 \times \frac{1}{[\text{O}_2]} = 100$$

$$\text{then } \frac{4}{[\text{O}_2]} = 100 \quad \text{or} \quad [\text{O}_2] = \frac{4}{100} \text{ mol L}^{-1}$$

$$\therefore \text{O}_2 \text{ present in } 10 \text{ L} = \frac{4}{100} \times 10 = 0.4 \text{ mol}$$

24. $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$

Initial pressure (atm) 0.5 0.5 0
 At equilibrium $(0.5 - x)$ $(0.5 - x)$ $2x$

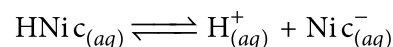
$$K_p = \frac{p_{\text{HI}}^2}{p_{\text{H}_2} \times p_{\text{I}_2}}, \quad 49 = \frac{(2x)^2}{(0.5 - x)^2} \quad \text{or} \quad \frac{2x}{0.5 - x} = 7$$

$$\text{or } 2x = 7(0.5 - x); 9x = 3.5; x = 0.39$$

$$\therefore \text{Pressure of } \text{H}_2 \text{ and } \text{I}_2 \text{ at equilibrium} = (0.5 - x)$$

$$= 0.5 - 0.39 = 0.11 \text{ atm}$$

25. Let degree of dissociation = α



Initial amount (mol) 0.1 0 0
 At equilibrium $0.1(1 - \alpha)$ 0.1α 0.1α
 Concentration at equilibrium (mol L⁻¹) $\frac{0.1(1 - \alpha)}{2}$ $\frac{0.1\alpha}{2}$ $\frac{0.1\alpha}{2}$
 $= 0.05(1 - \alpha)$ $= 0.05\alpha$ $= 0.05\alpha$

$$K_a = \frac{[\text{H}^+][\text{Ni c}^-]}{[\text{HNic}]} = \frac{(0.05\alpha)(0.05\alpha)}{0.05(1 - \alpha)}$$

Assuming $\alpha \ll 1$, $\therefore K_a = 0.05\alpha^2$

$$\alpha^2 = \frac{1.4 \times 10^{-4}}{0.05} = 28 \times 10^{-4}$$

$$\alpha = 5.29 \times 10^{-2} = 0.053$$

$$\text{Percentage dissociation} = 0.053 \times 100 = 5.3 \%$$

26. Applying,

$$\frac{\text{Strength of benzoic acid}}{\text{Strength of phenol}} = \sqrt{\frac{K_a(\text{benzoic acid})}{K_a(\text{phenol})}}$$

$$= \sqrt{\frac{6.5 \times 10^{-5}}{1.3 \times 10^{-10}}} = 7.07 \times 10^2$$

i.e., strength of benzoic acid = $7.07 \times 10^2 \times$ strength of phenol.

27. Concentration of HCl after dilution

$$= \frac{10^{-6}}{100} = 10^{-8} \text{ M}$$

$$\text{Hence, } [\text{H}^+] = 10^{-8} \text{ M}$$

Since, concentration of $[\text{H}^+]$ from acid is very low, concentration of H^+ from water is also taken into account.

$$[\text{H}^+] \text{ from water} = 10^{-7} \text{ M}$$

$$\text{Total } [\text{H}^+] = (10^{-8} + 10^{-7}) = 1.1 \times 10^{-7} \text{ M}$$

$$\text{pH} = -\log [\text{H}^+] = -\log (1.1 \times 10^{-7})$$

$$= 7 - \log 1.1 = 6.95$$

28. $\text{Al}(\text{OH})_3 \rightleftharpoons \text{Al}^{3+} + 3\text{OH}^-$

$$K_{sp} = [\text{Al}^{3+}][\text{OH}^-]^3 = (s)(3s)^3 = 27s^4$$

$$s^4 = \frac{K_{sp}}{27} = \frac{2.7 \times 10^{-11}}{27} = 1 \times 10^{-12}$$

$$s = 1 \times 10^{-3} \text{ mol L}^{-1}$$

Molar mass of $\text{Al}(\text{OH})_3 = 78 \text{ g mol}^{-1}$

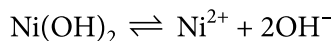
Solubility of $\text{Al}(\text{OH})_3$ in $\text{g L}^{-1} = 1 \times 10^{-3} \times 78$
 $= 78 \times 10^{-3} = 7.8 \times 10^{-2} \text{ g L}^{-1}$

$$[\text{OH}^-] = 3s = 3 \times 1 \times 10^{-3} = 3 \times 10^{-3}$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log(3 \times 10^{-3}) = 2.522$$

$$\text{pH} = 14 - \text{pOH} = 14 - 2.522 = 11.4778$$

OR



$$K_{sp} = [\text{Ni}^{2+}][\text{OH}^-]^2 = 2 \times 10^{-15}$$

Suppose $[\text{Ni}^{2+}] = s_2$, $[\text{OH}^-] = 2s_2$

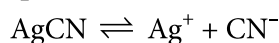
$$\text{So, } s_2 \times (2s_2)^2 = 2 \times 10^{-15} \Rightarrow 4s_2^3 = 2 \times 10^{-15}$$

$$\Rightarrow s_2^3 = 0.5 \times 10^{-15} \Rightarrow s_2^3 = 5 \times 10^{-16}$$

$$\Rightarrow s_2^3 = 500 \times 10^{-18}$$

$$\Rightarrow s_2 = \sqrt[3]{500 \times 10^{-18}} = 7.9 \times 10^{-6} \text{ M}$$

$$s_2 = 7.9 \times 10^{-6} \text{ M}$$



$$K_{sp} = [\text{Ag}^+][\text{CN}^-] = 6 \times 10^{-17}$$

Suppose $[\text{Ag}^+] = [\text{CN}^-] = s_1$

$$\text{So, } s_1^2 = 6 \times 10^{-17} \Rightarrow s_1 = \sqrt{60 \times 10^{-18}}$$

$$\Rightarrow s_1 = 7.7 \times 10^{-9} \text{ M}$$

Since $s_2 > s_1$, therefore $\text{Ni}(\text{OH})_2$ is more soluble than AgCN .

$$\text{29. (a)} \quad [\text{H}^+] = 4 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log [\text{H}^+] = -\log [4 \times 10^{-3}] = -\log 4 + 3$$

$$= -0.6020 + 3 = 2.398 \approx 2.4$$

OR

$$\text{pH} = -\log [\text{H}^+] = 6.58$$

$$\log [\text{H}^+] = -6.58$$

$$[\text{H}^+] \text{ or } [\text{H}_3\text{O}^+] = 2.63 \times 10^{-7} \text{ M}$$

(b) Ammonium acetate is a salt of weak acid and weak base.

$$\text{pH} = \frac{1}{2} [\text{p}K_w + \text{p}K_a - \text{p}K_b]$$

$$= \frac{1}{2} [14 - \log(1.8 \times 10^{-5}) + \log(1.8 \times 10^{-5})] = 7.0$$

(c) Given, $\text{pH} = 3$ means $[\text{H}^+] = 10^{-3}$ in 1 L solution.

Then in 250 mL, no. of moles of H^+ ions

$$= \frac{250 \times 10^{-3}}{1000} = 2.5 \times 10^{-4}$$

$$\therefore \text{No. of } \text{H}^+ \text{ ions in } 2.5 \times 10^{-4} \text{ moles}$$

$$= 6.023 \times 10^{23} \times 2.5 \times 10^{-4} = 1.506 \times 10^{20}$$

30. (a) It is ternary electrolyte,

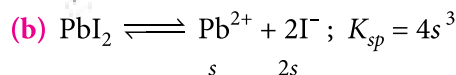


Let solubility of CaF_2 be $s \text{ mol litre}^{-1}$

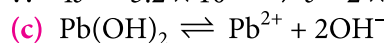


$$K_{sp} = [\text{Ca}^{2+}][\text{F}^-]^2 = (s) \times (2s)^2 = 4s^3$$

$$s = \sqrt[3]{\frac{K_{sp}}{4}}$$



$$\therefore 4s^3 = 3.2 \times 10^{-8} \Rightarrow s = 2 \times 10^{-3} \text{ M}$$



$$\therefore K_{sp} = [\text{Pb}^{2+}][\text{OH}^-]^2 = s \times (2s)^2 = 4s^3$$

$$= 4 \times (6.7 \times 10^{-6})^3 = 1.20 \times 10^{-15}$$

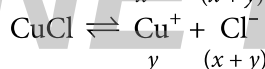
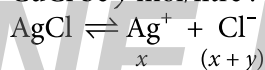
In a solution with $\text{pH} = 8$, $[\text{H}^+] = 10^{-8}$ and $[\text{OH}^-] = 10^{-6}$

$$\therefore 1.2 \times 10^{-15} = [\text{Pb}^{2+}] \times (10^{-6})^2$$

$$\text{or } [\text{Pb}^{2+}] = \frac{1.2 \times 10^{-15}}{(10^{-6})^2} = 1.2 \times 10^{-3} \text{ M}$$

OR

Let the concentration of AgCl be $x \text{ mol/litre}$ and that of CuCl be $y \text{ mol/litre}$:



$$K_{sp} \text{ of } \text{AgCl} = [\text{Ag}^+][\text{Cl}^-] = x(x+y) \quad \dots\text{(i)}$$

$$K_{sp} \text{ of } \text{CuCl} = [\text{Cu}^+][\text{Cl}^-] = y(x+y) \quad \dots\text{(ii)}$$

On solving (i) and (ii), we get

$$\frac{K_{sp} \text{ of } \text{AgCl}}{K_{sp} \text{ of } \text{CuCl}} = \frac{x}{y} \Rightarrow \frac{1.6 \times 10^{-10}}{1.0 \times 10^{-6}} = \frac{x}{y}$$

$$\Rightarrow x = 1.6 \times 10^{-5} \text{ mol/litre}$$

31. (a)	$\text{S}_8 \rightleftharpoons 4\text{S}_2$
Initial pressure (atm)	1 0
At equilibrium	$1 - 0.29$ 4×0.29
	$= 0.71$ $= 1.16$

$$\text{we know, } K_p = \frac{p_{\text{S}_2}^4}{p_{\text{S}_8}} = \frac{(1.16)^4}{0.71} = 2.55 \text{ atm}^3$$



$$Q = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{0.2 \times 0.6}{0.4} = 0.3$$

but $K_c = 0.2$ i.e., $Q > K_c$

Therefore, reaction proceeds from right to left i.e., in backward direction.

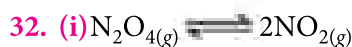
(c) When an equilibrium is subjected to any kind of stress (change in concentration, temperature or pressure), it shifts in a direction so as to undo the effect of stress.

(d) On reducing volume, pressure will increase. According to Le-Chatelier's principle, equilibrium will shift to the side accompanied by decrease of pressure or decrease in number of gaseous mole *i.e.*, backward reaction.

(e) The value of equilibrium constant will decrease as the temperature increases for an exothermic reaction.

(f) $\Delta G^\circ = -RT \ln K_c$
 $\Delta G^\circ = -8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 300 \text{ K} \ln (2 \times 10^{13})$
 $\Delta G^\circ = -7.64 \times 10^4 \text{ J mol}^{-1}$

(g) As the reaction is exothermic, hence on decreasing the temperature, the reaction will move in forward direction. On the other hand, on increasing the pressure, the reaction will move towards the lesser number of moles, *i.e.*, forward direction. Thus to yield maximum SO_3 , low temperature and high pressure is required.



Mol. mass of $\text{N}_2\text{O}_4 = (28 + 64) = 92 \text{ g mol}^{-1}$

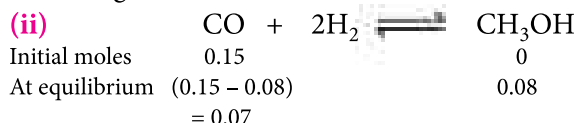
Vapour density, $D = \frac{92}{2} = 46$

Let the degree of dissociation be x .

Applying the relationship,

$$x = \frac{D-d}{d} = \frac{(46-30)}{30} = \frac{16}{30} = 0.533 \text{ (Given, } d = 30\text{)}$$

Percentage dissociation = 53.3%



Applying $PV = nRT$

$P = 8.5 \text{ atm}$ $V = 2.5 \text{ L}$

$R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$, $T = 750 \text{ K}$

$$n = \frac{PV}{RT} = \frac{8.5 \times 2.5}{0.0821 \times 750} = 0.345 \text{ moles}$$

So, total number of moles at equilibrium = 0.345 moles

$\therefore$ Number of moles of H_2 at equilibrium
 $= 0.345 - (0.07 + 0.08) = 0.195$

$$K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}][\text{H}_2]^2} = \frac{(0.08/2.5)}{(0.07/2.5)(0.195/2.5)^2} = 187.8$$

OR

(i) (a) Vapour pressure remains constant.

(b) Soda - water bottle is an example of gas $\rightleftharpoons$ solution equilibrium.

(ii) Catalyst affects both forward and backward reactions at the same extent, hence it does not alter the equilibrium, it can only help in attaining the equilibrium faster.

(iii) At equilibrium, reaction does not stop rather it still continues, thus the equilibrium is dynamic in nature. It appears to stop as rate of forward reaction is equal to rate of backward reaction.

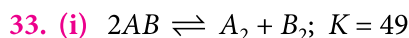
(iv) Applying $K_a = C\alpha^2$,

$$C = 0.01, \alpha = \frac{14.5}{100} = 0.145$$

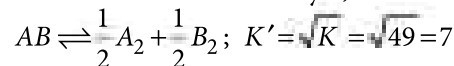
$$K_a = 0.01 \times (0.145)^2 = 2.1 \times 10^{-4}$$

(v) We know $\text{pH} = -\log [\text{H}^+]$

It can be easily interpreted that to raise the pH by 2 units, $[\text{H}^+]$ should be decreased 10^2 *i.e.*, 100 times.



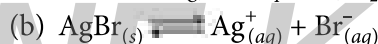
If we divide the reaction by 2,



$$K_c = \frac{[\text{BaO}_{(s)}][\text{CO}_{2(g)}]}{[\text{BaCO}_{3(s)}]}$$

By convention, $[\text{BaO}_{(s)}] = 1$ and $[\text{BaCO}_{3(s)}] = 1$

$$\therefore K_c = [\text{CO}_{2(g)}] \text{ or } K_p = p_{(\text{CO}_2)}$$



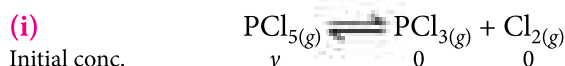
$$K_c = \frac{[\text{Ag}^+_{(aq)}][\text{Br}^-_{(aq)}]}{[\text{AgBr}_{(s)}]}$$

$$\text{or } K_c = [\text{Ag}^+_{(aq)}][\text{Br}^-_{(aq)}] \quad ([\text{AgBr}_{(s)}] = 1)$$

(iii) $K_p = K_c (RT)^{\Delta n_g}$

$$\Delta n_g = (2 - 1) = 1; K_p = K_c (RT)^1 = K_c RT$$

OR



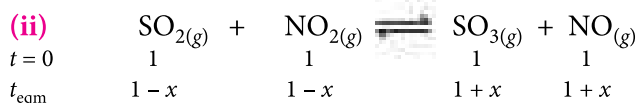
Conc. at equilibrium $y - x$ x x

But $y - x = 0.5 \times 10^{-1} \text{ mol L}^{-1}$

$$\therefore K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{x \cdot x}{(y-x)} = \frac{x^2}{0.5 \times 10^{-1}} = 8.3 \times 10^{-3}$$

$$\Rightarrow x = 2.04 \times 10^{-2} \text{ mol L}^{-1}$$

$$[\text{PCl}_3] = [\text{Cl}_2] = 2.04 \times 10^{-2} \text{ mol L}^{-1}$$

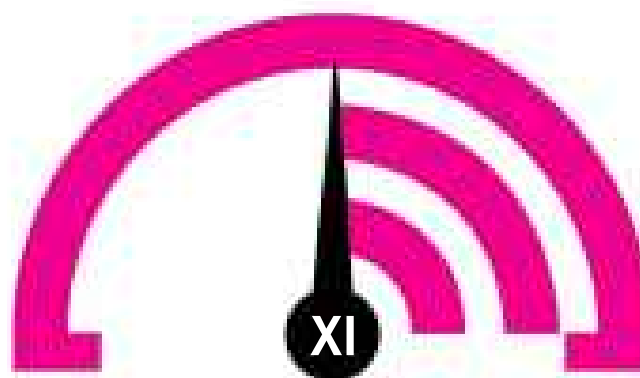


$$\text{Hence, } K_c = \frac{[\text{SO}_3][\text{NO}]}{[\text{SO}_2][\text{NO}_2]} = \frac{(1+x)^2}{(1-x)^2} = 16$$

$$\text{or } \frac{1+x}{1-x} = 4 \quad \text{or } x = \frac{3}{5} \text{ mol} = 0.6 \text{ mol}$$

$$\text{Hence, } [\text{NO}_2] = 0.4 \text{ mol L}^{-1} \text{ and } [\text{NO}] = 1.6 \text{ mol L}^{-1}.$$

MONTHLY TEST DRIVE



This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Structure of Atom | Classification of Elements and Periodicity in Properties

Time Taken : 60 Min.

NEET

Only One Option Correct Type

- Select the correct statement.
 - The value of spin only magnetic moment of Co^{3+} ion (in B.M.) = $\sqrt{24}$.
 - The number of radial nodes in a $3p$ -orbital = 1.
 - The number of unpaired electrons in Mn^{2+} ion = 5.
 - All are correct.
- Which of the following elements shown as pairs with their atomic numbers belong to the same period?
 - $Z = 19$ and $Z = 38$
 - $Z = 12$ and $Z = 17$
 - $Z = 11$ and $Z = 21$
 - $Z = 16$ and $Z = 35$
- As per de-Broglie's formula, a macroscopic particle of mass 100 g, moving at a velocity of 100 cm s^{-1} will have a wavelength of
 - $6.6 \times 10^{-29} \text{ cm}$
 - $6.6 \times 10^{-30} \text{ cm}$
 - $6.6 \times 10^{-31} \text{ cm}$
 - $6.6 \times 10^{-32} \text{ cm}$
- Which of the following statements is incorrect in relation to ionisation enthalpy?
 - Ionisation enthalpy generally increases for removal of each successive electron.
 - The greatest increase in ionisation enthalpy is experienced on removal of electron from core noble gas configuration.
 - End of valence electron is marked by a big jump in ionisation enthalpy.
 - Removal of electron from orbitals bearing lower n values is easier than from orbital having higher n values.
- Calculate the longest wavelength (in $\text{\AA}$) which can remove the electron from first Bohr's orbit. (Given : $E_1 = 13.6 \text{ eV}$)
 - 303.81
 - 912.24
 - 1095.12
 - 1215.67
- Elements X, Y and Z have atomic numbers 19, 37 and 55 respectively. Which of the following statements is true about them?
 - Their ionization potential would increase with increasing atomic number.
 - Y would have an ionization potential between those of X and Z.
 - Z would have the highest ionization potential.
 - Y would have the highest ionization potential.
- Which of the following is not a correct statement regarding the energies of orbitals?
 - The lower the value of $(n + l)$ for an orbital, lower is its energy.
 - Electrons in the same subshell have equal energy.
 - Energy of s -orbital is lower than the p -orbital and that of p -orbital is lower than the d -orbital.
 - If two orbitals have same value for $(n + l)$, the orbital with higher value of n will have lower energy.
- Which of the following decreases down the group in periodic table?
 - Basic nature of oxides
 - Non-metallic character
 - Electronegativity
 - Both (b) and (c)

9. The first, second and third ionization enthalpies of an element are 737, 1450 and 7731 kJ mol⁻¹ respectively. What will be the formulae of its oxide and chloride?
- (a) M₂O, MCl (b) MO, MCl₂
(c) M₂O₃, MCl₃ (d) MO₂, MCl₄
10. The bromine atom possesses 35 electrons. It contains 6 electrons in 2p-orbital, 6 electrons in 3p-orbital and 5 electrons in 4p-orbital. Which of these electrons experiences the lowest effective nuclear charge?
- (a) 2p (b) 3p
(c) 4p
(d) All experience equal nuclear charge.
11. How many elements would be in the 2nd period of the Periodic Table if the spin quantum numbers could have the value $+\frac{1}{2}, 0, -\frac{1}{2}$?
- (a) 18 (b) 12 (c) 10 (d) 8
12. When the following five anions are arranged in order of decreasing ionic radius, the correct sequence is
- (a) Se²⁻, I⁻, Br⁻, O²⁻, F⁻
(b) I⁻, Se²⁻, O²⁻, Br⁻, F⁻
(c) Se²⁻, I⁻, Br⁻, F⁻, O²⁻
(d) I⁻, Se²⁻, Br⁻, O²⁻, F⁻

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

- (a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.
13. **Assertion :** Metallic character is highest at the extremely left side of the periodic table.
Reason : Ionisation enthalpy decreases across a period.
14. **Assertion :** In hydrogen and hydrogen like species, orbital energy depends only on the quantum number n , whereas in multi-electron atoms it depends on quantum numbers n and l .
Reason : The principal quantum number determines the size and the energy of the orbital.

15. **Assertion :** In the present form of the periodic table, the period number corresponds to the highest principle quantum number (n) of the elements in the period.

Reason : The first period in the long form of the periodic table contains 8 elements.

JEE (Main & Advanced)

Only One Option Correct Type

16. (A), (B), (C) are elements in the third period of the periodic table. Oxide of (A) is ionic, that of (B) is amphoteric and of (C) a giant molecule. (A) (B) and (C) will have atomic number in the order
- (a) (A) < (B) < (C) (b) (C) < (B) < (A)
(c) (A) < (C) < (B) (d) (B) < (A) < (C)
17. Energy of an electron is given by $E = -2.178 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n^2} \right)$. Wavelength of light required to excite an electron in an hydrogen atom from level $n = 1$ to $n = 2$ will be ($h = 6.62 \times 10^{-34} \text{ J s}$ and $c = 3.0 \times 10^8 \text{ m s}^{-1}$)
- (a) $8.500 \times 10^{-7} \text{ m}$ (b) $1.214 \times 10^{-7} \text{ m}$
(c) $2.816 \times 10^{-7} \text{ m}$ (d) $6.500 \times 10^{-7} \text{ m}$

CHEM CAPSULE

Where did the chemist had his lunch?



"ON A PERIODIC TABLE"

18. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides?

(a) $\text{Al}_2\text{O}_3 < \text{MgO} < \text{Na}_2\text{O} < \text{K}_2\text{O}$
 (b) $\text{MgO} < \text{K}_2\text{O} < \text{Al}_2\text{O}_3 < \text{Na}_2\text{O}$
 (c) $\text{Na}_2\text{O} < \text{K}_2\text{O} < \text{MgO} < \text{Al}_2\text{O}_3$
 (d) $\text{K}_2\text{O} < \text{Na}_2\text{O} < \text{Al}_2\text{O}_3 < \text{MgO}$

19. If the radius of 2nd Bohr orbit of hydrogen atom is r_2 . The radius of third Bohr orbit will be :

(a) $\frac{4}{9}r_2$ (b) $4r_2$ (c) $\frac{9}{4}r_2$ (d) $9r_2$

More than One Option Correct Type

20. Identify the correct statements.

The findings from the Bohr model for H-atom are

(a) angular momentum of the electron is expressed as integral multiples of $h/2\pi$
 (b) the first Bohr radius is $0.529 \text{ \AA}$
 (c) the energy of the n^{th} level, E_n is proportional to $\frac{1}{n^2}$
 (d) the spacing between adjacent levels remains constant with increase in value of ' n '.

21. Which of the following are incorrect statements?

(a) The electron affinity of Si is greater than that of P.
 (b) Penetrating power of p -orbital is more than s -orbital.
 (c) The numerical value of electronegativity of an atom is independent of its ionisation potential and electron affinity.
 (d) A positive ion is always smaller in size than its parent atom.

22. Which of the following statements are correct?

(a) The electronic configuration of Cr is $[\text{Ar}]3d^54s^1$.
 (b) The magnetic quantum number may have a negative value.
 (c) Bohr's model of hydrogen atom could not explain the ability of atoms to form molecules by chemical bonds.
 (d) The principal quantum number determines the three-dimensional shape of the orbital.

23. The options with only acidic oxides are

(a) Cr_2O_3 , BeO , SnO , SnO_2
 (b) ZnO , Al_2O_3 , PbO , PbO_2
 (c) NO_2 , CO_2 , SiO_2 , SO_2
 (d) V_2O_5 , GeO_2 , NO_2 , SiO_2

Integer / Numerical Value Type

24. An electron is moving with kinetic energy of $4.55 \times 10^{-25} \text{ J}$. Its wavelength is $\text{_____} \times 10^{-7} \text{ nm}$.
 [Given : mass of an electron = $9.1 \times 10^{-31} \text{ kg}$ and $h = 6.6 \times 10^{-34} \text{ kg m}^2 \text{ s}^{-1}$]

Chemistry bulletin

Synthesis of a glycan hairpin!

The primary sequence of a biopolymer encodes the essential information for folding, permitting to carry out sophisticated functions. Inspired by natural biopolymers, peptide and nucleic acid sequences have been designed to adopt particular three-dimensional (3D) shapes and programmed to exert specific functions. In contrast, synthetic glycans capable of autonomously folding into defined 3D conformations have so far not been explored owing to their structural complexity and lack of design rules. Here we generate a glycan that adopts a stable secondary structure not present in nature, a glycan hairpin, by combining natural glycan motifs, stabilized by a non-conventional hydrogen bond and hydrophobic interactions. Automated glycan assembly enabled rapid access to synthetic analogues, including site-specific ^{13}C labelled ones, for nuclear magnetic resonance conformational analysis. Long-range inter-residue nuclear Overhauser effects unequivocally confirmed the folded conformation of the synthetic glycan hairpin. The capacity to control the 3D shape across the pool of available monosaccharides has the potential to afford more foldamer scaffolds with programmable properties and functions. The design was based on the combination of natural glycan structural elements and aided by molecular dynamics (MD) simulations. Automated glycan assembly (AGA) provided rapid access to a series of well-defined glycan sequences, including ^{13}C -labelled analogues to facilitate the structural and conformational analysis. Nuclear magnetic resonance (NMR) spectroscopy detected long-range inter-residue nuclear Overhauser effects (NOEs) that unequivocally confirmed the folded conformation of the synthetic glycan hairpin. This work demonstrates that it is possible to program glycans adopting defined conformation in aqueous solution, opening opportunities for endowing glycans with new properties and functions.



25. Using the following data, calculate the electronegativity of fluorine.

$$E_{\text{H}-\text{H}} = 104.2 \text{ kcal mol}^{-1}, E_{\text{F}-\text{F}} = 36.6 \text{ kcal mol}^{-1}$$

$$E_{\text{H}-\text{F}} = 134.6 \text{ kcal mol}^{-1}, \chi_{\text{H}} = 2.1.$$

26. Consider a helium (He) atom that absorbs a photon of wavelength 330 nm. The change in the velocity (in cm s^{-1}) of He atom after the photon absorption is _____.

(Assume: Momentum is conserved when photon is absorbed. Use: Planck constant = $6.6 \times 10^{-34} \text{ J s}$, Avogadro number = $6 \times 10^{23} \text{ mol}^{-1}$, Molar mass of He = 4 g mol^{-1})

Comprehension Type

Atomic radii is defined as the distance between the nucleus and outermost shell of an ion or it is the distance between the nucleus and the point where the nucleus exerts its influence on the electron cloud. Metal ions are smaller than the atoms from which they are formed. When a positive ion is formed, the number of positive charges on the nucleus exceeds the number of orbital electrons, and the effective nuclear charge is increased. This results in the remaining electrons being more strongly attracted by the nucleus. These electrons are pulled in further reducing the size. A positive ion is thus always smaller than the corresponding atom, and more the number of electrons which are removed, the smaller the ion becomes.

The negative ion is always larger than that of the corresponding atom. Negative ion is formed by gain of one or more electrons in the neutral atom and thus number of electrons increases but magnitude of nuclear charge remains the same.

27. The ions O^{2-} , F^- , Na^+ , Mg^{2+} and Al^{3+} are isoelectronic. Their ionic radii show
- a decrease from O^{2-} to F^- and then increase from Na^+ to Al^{3+}
 - a significant increase from O^{2-} to Al^{3+}
 - a significant decrease from O^{2-} to Al^{3+}
 - an increase from O^{2-} to F^- and then decrease from Na^+ to Al^{3+} .

28. Which of the following statements is correct?

- X^- ion is larger in size than X atom.
- X^+ ion is larger in size than X atom.
- X^+ and X^- ions are equal in size.
- X^+ ion is larger in size than X^- ion.

Matching Type

29. Match the element in Column I with its corresponding property in Column II and mark the appropriate choice.

Column I	Column II
(A) F	(i) Maximum electron affinity
(B) Cl	(ii) Maximum electronegativity
(C) Br	(iii) Exists as X_2 in liquid state
(D) I	(iv) Exists as X_2 in solid state
(E) At	(v) X_2 sublimates on heating
	(vi) X_2 is the best oxidising agent
	(vii) Radioactive element

- (A) $\rightarrow$ (ii, vi), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (iv, v), (E) $\rightarrow$ (vii)
- (A) $\rightarrow$ (i), (B) $\rightarrow$ (iii, iv), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (ii, iv), (E) $\rightarrow$ (v, vi)
- (A) $\rightarrow$ (ii, vi), (B) $\rightarrow$ (iii, v), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (v), (E) $\rightarrow$ (vii)
- (A) $\rightarrow$ (i), (B) $\rightarrow$ (vi, vii), (C) $\rightarrow$ (v), (D) $\rightarrow$ (iv), (E) $\rightarrow$ (ii, iii)

30. Match species given in Column I with the electronic configuration given in Column II.

Column I	Column II
(A) Cr	(i) $[\text{Ar}]3d^84s^0$
(B) Fe^{2+}	(ii) $[\text{Ar}]3d^{10}4s^1$
(C) Ni^{2+}	(iii) $[\text{Ar}]3d^64s^0$
(D) Cu	(iv) $[\text{Ar}]3d^54s^1$

- (A) $\rightarrow$ (iv), (B) $\rightarrow$ (i), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iii)
- (A) $\rightarrow$ (iv), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (i), (D) $\rightarrow$ (ii)
- (A) $\rightarrow$ (iii), (B) $\rightarrow$ (ii), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (i)
- (A) $\rightarrow$ (ii), (B) $\rightarrow$ (iv), (C) $\rightarrow$ (i), (D) $\rightarrow$ (iii)

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted
No. of questions correct
Marks scored in percentage

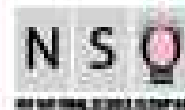
Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

Are you ready for Olympiads?

LEVEL-I Exam on

17th Oct, 21st Nov & 5th Dec 2023



CLASS XI

SYLLABUS*

Section – 1 : Physics : Units and Measurements, Mechanics, Properties of Matter, Heat and Thermodynamics, Oscillations, Waves. Chemistry : Some Basic Concepts of Chemistry, Structure of Atom, Classification of Elements and Periodicity in Properties, Chemical Bonding and Molecular Structure, States of Matter, Thermodynamics, Equilibrium, Redox Reactions, Hydrogen, The s-Block Elements, The p-Block Elements (Groups 13 and 14), Organic Chemistry - Some Basic Principles and Techniques, Hydrocarbons, Environmental Chemistry.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section – 1.

Total Questions : 50

Time : 1 hr.

PATTERN & MARKING SCHEME

Section	(1) Physics & Chemistry	(2) Achievers Section	(3) Mathematics or Biology
No. of Questions	25	5	20
Marks per Ques.	1	3	1

Section – 3 : Sets, Relations and Functions, Principle of Mathematical Induction, Logarithms, Complex Numbers & Quadratic Equations, Linear Inequalities, Sequences and Series, Trigonometry, Straight Lines, Conic Sections, Permutations and Combinations, Binomial Theorem, Statistics, Mathematical Reasoning, Limits and Derivatives, Probability, Introduction to 3-D Geometry.

OR

Section – 3 : Diversity in the Living World, Structural Organisation in Plants and Animals, Cell : Structure and Functions, Plant Physiology, Human Physiology.

Practice Questions

- A sample of NaClO_3 is converted by heat to NaCl with a loss of 0.16 g of oxygen. The residue is dissolved in water and precipitated as AgCl . The mass of AgCl (in g) obtained will be
(Given : Molar mass of $\text{AgCl} = 143.5 \text{ g mol}^{-1}$)
A. 0.54 B. 0.35
C. 0.48 D. 0.4
- If the given four electronic configurations
(i) $n = 4, l = 1$ (ii) $n = 4, l = 0$
(iii) $n = 3, l = 2$ (iv) $n = 3, l = 1$
are arranged in order of increasing energy, then the order will be
A. (iv) < (ii) < (iii) < (i)
B. (ii) < (iv) < (i) < (iii)
C. (i) < (iii) < (ii) < (iv)
D. (iii) < (i) < (iv) < (ii)
- For one of the element various successive ionisation enthalpies (in kJ mol^{-1}) are given below :

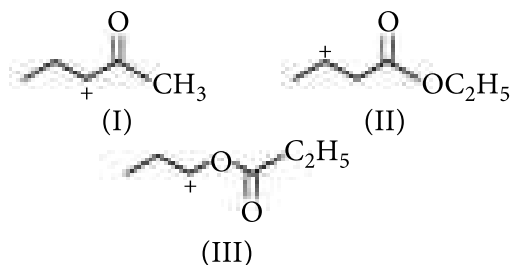
I.E.	1 st	2 nd	3 rd	4 th	5 th
	577.5	1810	2750	11,580	14,820

The element is
A. P B. Mg
C. Si D. Al
- Which one of the following is not correct in respect to hybridization of orbitals?
A. The orbitals present in the valence shell only are hybridized.
B. The orbitals undergoing hybridization have almost equal energy.
C. Promotion of electron is not essential condition for hybridization.
D. It is not always that only partially filled orbitals participate in hybridization, in some cases even filled orbitals in valence shell take part.
- Given are the bond enthalpies: $\Delta H_{(\text{N}\equiv\text{N})} = 945 \text{ kJ mol}^{-1}$, $\Delta H_{(\text{H}-\text{H})} = 436 \text{ kJ mol}^{-1}$ and $\Delta H_{(\text{N}-\text{H})} = 391 \text{ kJ mol}^{-1}$. The enthalpy change of the reaction
 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ is
A. -93 kJ mol^{-1} B. -89 kJ mol^{-1}
C. -105 kJ mol^{-1} D. 105 kJ mol^{-1}
- The following two equilibria exist simultaneously in a closed vessel:
 $\text{PCl}_5(\text{g}) \rightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \quad \dots\text{(i)}$
 $\text{COCl}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{Cl}_2(\text{g}) \quad \dots\text{(ii)}$
If some CO is added into the vessel, then after the equilibrium is attained again, concentration of
A. PCl_5 will increase
B. PCl_5 will decrease
C. PCl_5 will remain unaffected
D. Cl_2 will increase.

7. Consider the following reaction showing the conversion of chromite into soluble chromium salt
- $$4\text{Fe}(\text{CrO}_2)_2 + 8\text{Na}_2\text{CO}_3 + 7\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3 + 8\text{NaCrO}_4 + 8\text{CO}_2$$

Select the correct statement.

- A. Oxidation of Fe and Cr both and reduction of oxygen.
 B. Oxidation of Fe and reduction of Cr.
 C. Oxidation of Fe and Cr both and reduction of carbon.
 D. No redox reaction.
8. The correct order of stability of the following carbocation is



- A. III > II > I
 B. III > I > II
 C. I > II > III
 D. I > III > II
9. In the given conformation, C_2 is rotated about $\text{C}_2 - \text{C}_3$ bond in anticlockwise direction by an angle of 120° , then the conformation obtained is
-
- A. Fully eclipsed conformation
 B. Partially eclipsed conformation
 C. Gauche conformation
 D. Staggered conformation
10. In an isothermal reversible compression of an ideal gas, the signs of q , ΔS and w are
- | | q | ΔS | w |
|----|-----|------------|-----|
| A. | + | - | - |
| B. | - | + | - |
| C. | + | - | + |
| D. | - | - | + |
11. Addition of sodium acetate to 0.1 M acetic acid will cause
- A. Increase in pH
 B. Decrease in pH
 C. No change in pH
 D. Change in pH that cannot be predicted
12. Given $E^\circ_{\text{Cr}^{3+}/\text{Cr}} = -0.74 \text{ V}$; $E^\circ_{\text{MnO}_4^-/\text{Mn}^{2+}} = 1.51 \text{ V}$
 $E^\circ_{\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}} = 1.33 \text{ V}$; $E^\circ_{\text{Cl}^-/\text{Cl}_2} = 1.36 \text{ V}$

Based on the data given above, strongest oxidising agent will be

- A. MnO_4^-
 B. Cl^-
 C. Cr^{3+}
 D. Mn^{2+}

13. Which of the following statements is not true about partition chromatography?
- A. Mobile phase can be a gas.
 B. Separation depends upon equilibration of solute between a mobile and a stationary phase.
 C. Paper chromatography is an example of partition chromatography.
 D. Stationary phase is a finely divided solid adsorbent.
14. Consider the following ionization enthalpies of two elements 'P' and 'Q':

Element	Ionization enthalpy (kJ/mol)		
	1 st	2 nd	3 rd
P	899	1757	14847
Q	737	1450	7731

Which of the following statements is correct?

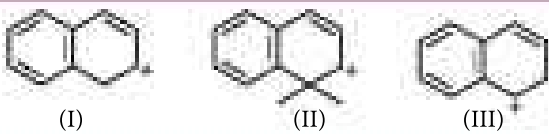
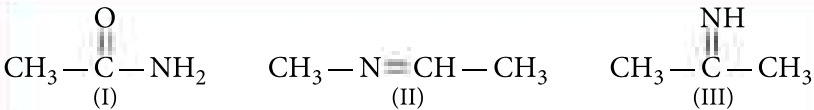
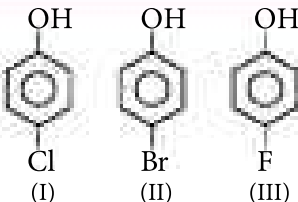
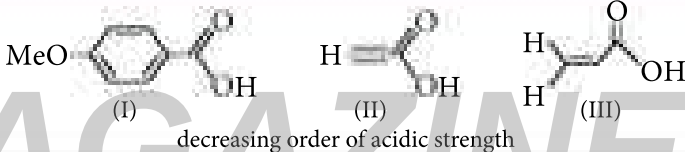
- A. Both 'P' and 'Q' belong to group-2 where 'P' comes below 'Q'.
 B. Both 'P' and 'Q' belong to group-2 where 'Q' comes below 'P'.
 C. Both 'P' and 'Q' belong to group-1 where 'Q' comes below 'P'.
 D. Both 'P' and 'Q' belong to group-1 where 'P' comes below 'Q'.
15. **Assertion :** In the bonding molecular orbital of H_2 , electron density is increased between the nuclei.
Reason : The bonding MO is $\psi_A + \psi_B$, which shows destructive interference of the combining electron waves.
- A. Both assertion and reason are true and reason is the correct explanation of the assertion.
 B. Both assertion and reason are true but reason is not the correct explanation of the assertion.
 C. Assertion is true, but reason is false.
 D. Both assertion and reason are false.

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

- | | | | | |
|-----------|-------------|-----------|----------|-----------|
| 1. (a) | 2. (b) | 3. (c) | 4. (d) | 5. (d) |
| 6. (c) | 7. (b) | 8. (c) | 9. (a) | 10. (b) |
| 11. (d) | 12. (d) | 13. (c) | 14. (d) | 15. (c) |
| 16. (d) | 17. (d) | 18. (d) | 19. (a) | 20. (a,b) |
| 21. (a,c) | 22. (a,b,d) | 23. (a,d) | 24. (10) | 25. (9) |
| 26. (4) | 27. (b) | 28. (c) | 29. (a) | 30. (b) |

ACHIEVERS SECTION

16. Match the column I with column II and select the correct option from the given codes.

Column I (Compounds)			Column II (Order)	
(a)	 (I) (II) (III) decreasing order of carbocation stability		(p)	III > I > II
(b)	 (I) (II) (III) increasing order of basic strength		(q)	I > II > III
(c)	 (I) (II) (III) increasing order of pK _a		(r)	III > II > I
(d)	 (I) (II) (III) decreasing order of acidic strength		(s)	II > III > I

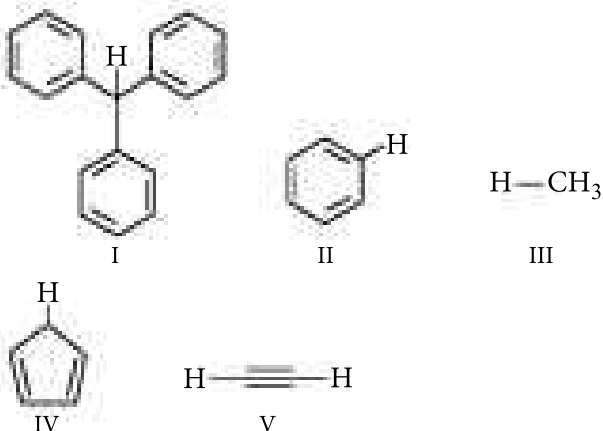
A. (a) → (q); (b) → (r); (c) → (p); (d) → (s)

C. (a) → (p); (b) → (q); (c) → (s); (d) → (r)

B. (a) → (s); (b) → (p); (c) → (q); (d) → (r)

D. (a) → (p); (b) → (s); (c) → (r); (d) → (q)

17. With respect to the compounds I-V, select the correct statements?



- The acidity of compound I is due to delocalization in its conjugate base.
- The conjugate base of compound IV is aromatic.
- Compound II becomes more acidic, when it has α-NO₂ substituent.
- The acidity of compounds follows the order : I > IV > V > II > III.

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CLASS 11



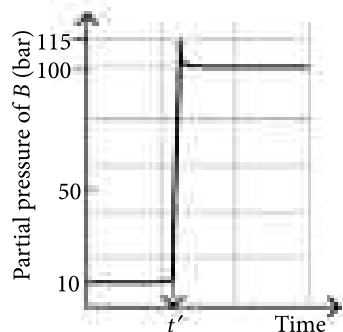
37

18. 29.2%(w/w) HCl stock solution has a density of 1.25 g mL^{-1} . The molecular weight of HCl is 36.5 g mol^{-1} . The volume (in mL) of stock solution required to prepare a 200 mL solution of 0.4 M HCl is

A. 9 mL B. 7 mL
C. 5 mL D. 8 mL

19. Consider the reaction, $A \rightleftharpoons B$ at 1000 K. At time t' , the temperature of the system was increased to 2000 K and the system was allowed to reach equilibrium.

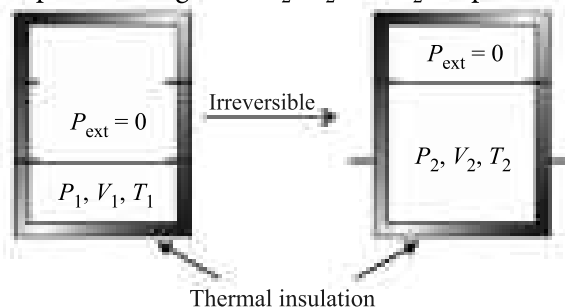
Throughout this experiment the partial pressure of A was maintained at 1 bar. Given here is the plot of the partial pressure of B with time.



The ratio of the standard Gibbs energy of the reaction at 1000 K to that at 2000 K is

A. 1.25 B. 2.75
C. 3.25 D. 0.25

20. An ideal gas in a thermally insulated vessel at internal pressure = P_1 , volume = V_1 and absolute temperature = T_1 expands irreversibly against zero external pressure, as shown in the diagram. The final internal pressure, volume and absolute temperature of gas are P_2 , V_2 and T_2 , respectively.



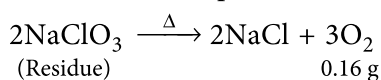
Which of the following is/are true for this expansion?

- I. $q = 0$ II. $T_2 = T_1$
III. $P_2 V_2 = P_1 V_1$ IV. $P_2 V_2^\gamma = P_1 V_1^\gamma$
A. I only B. II and IV only
C. I, II and III only D. II and III only

1. A B C D	5. A B C D	9. A B C D	13. A B C D	17. A B C D
2. A B C D	6. A B C D	10. A B C D	14. A B C D	18. A B C D
3. A B C D	7. A B C D	11. A B C D	15. A B C D	19. A B C D
4. A B C D	8. A B C D	12. A B C D	16. A B C D	20. A B C D

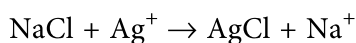
SOLUTIONS

1. (C) : Decomposition of NaClO_3 is given as :



$$\text{No. of moles of O}_2 \text{ formed} = \frac{0.16}{32} = 5 \times 10^{-3}$$

$$n_{\text{NaCl}} = \frac{2}{3} n_{\text{O}_2} = \frac{2}{3} \times 5 \times 10^{-3} = \frac{1}{300}$$



One mole of AgCl is precipitated from one mole of NaCl.

$$\therefore \text{Moles of AgCl} = \frac{1}{300}$$

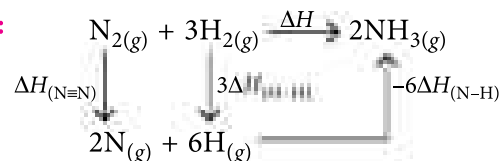
$$\begin{aligned} \therefore \text{Mass of AgCl} &= \text{Molar mass of AgCl} \times n_{\text{AgCl}} \\ &= 143.5 \times \frac{1}{300} \approx 0.48 \text{ g} \end{aligned}$$

2. (A)

3. (D) : Large jump between $I.E._3$ and $I.E._4$ suggests that the element has three valence electrons.

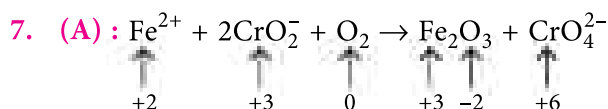
4. (C)

5. (A) :



$$\begin{aligned} \text{Hence, } \Delta H &= \Delta H_{(\text{N}=\text{N})} + 3\Delta H_{(\text{H}-\text{H})} - 6\Delta H_{(\text{N}-\text{H})} \\ &= (945 + 3 \times 436) - (6 \times 391) \text{ kJ mol}^{-1} \\ &= -93 \text{ kJ mol}^{-1} \end{aligned}$$

6. (B) : On adding CO, equilibrium (i) will shift backward. Hence concentration of Cl_2 will decrease. Decrease in concentration of Cl_2 will shift the equilibrium (i) in the forward direction, i.e., more PCl_5 will dissociate. Hence, concentration of PCl_5 will decrease.



Fe^{2+} and Cr^{3+} are oxidised (increase in oxidation number) and O_2 is reduced (decrease in oxidation number).

8. (A) : III is most stable due to the resonance stabilisation of oxygen at α -position.



I is least stable due to the presence of strong electron withdrawing carbonyl group adjacent to carbon.

9. (C) : When the anti-conformer is rotated by 120° , gauche conformer is obtained.

10. (D) : For isothermal reversible compression, work done (w) is +ve. As $q = -w$ therefore q is -ve.

Also, $\Delta S = \frac{q_{\text{iso, rev}}}{T}$. As q is -ve, so ΔS will also be -ve.

11. (A)

12. (A) : Greater the reduction potential of a substance, stronger is the oxidising agent.

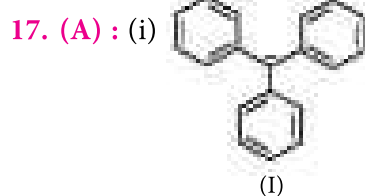
$\therefore \text{MnO}_4^-$ is the strongest oxidising agent.

13. (A) : In partition chromatography, mobile phase is liquid.

14. (B)

15. (C) : Bonding molecular orbital involves constructive interference.

16. (A)



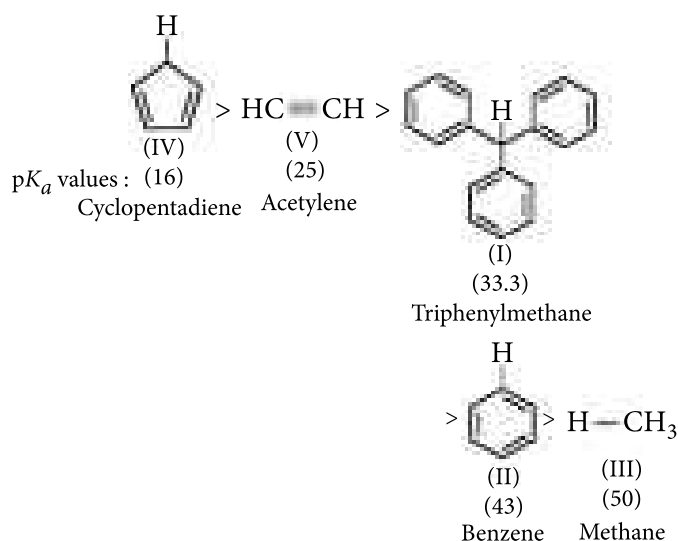
Conjugate base of compound (I) is stabilised due to delocalisation of -ve charge among three benzene rings. As a result of which (I) is acidic in nature.

(ii) Conjugate base of compound (IV) is aromatic in nature due to planarity and $(4n + 2) \pi$ -electrons (i.e., 6 π -electrons).



(iii) $-\text{NO}_2$ is an electron withdrawing group thus, it increases the acidic strength of any compound to which it is attached.

(iv) pK_a values give the order of acidic strength of given compounds. Smaller the pK_a value, more acidic will be the compound. The acidity of given compounds follows the order :



18. (D) : 29.2% (w/w) of HCl means

Mass of HCl(w) = 29.2 g

Mass of solution = 100 g

$d = 1.25 \text{ g/mL}$, mol. wt. of HCl = 36.5 g mol^{-1}

Volume of solution = $100 \text{ g} / 1.25 \text{ g mL}^{-1} = 80 \text{ mL}$

Molarity = $\frac{w / \text{mol. wt.}}{\text{Volume of solution}} \times 1000$

$$= \frac{(29.2 / 36.5)}{80} \times 1000 = 10 \text{ M}$$

Using $M_1 V_1 = M_2 V_2$

$$10 \times V_1 = 0.4 \times 200 \Rightarrow V_1 = \frac{200 \times 0.4}{10} = 8 \text{ mL}$$

19. (D) : Given : $T_1 = 1000 \text{ K}$, $T_2 = 2000 \text{ K}$,

$p_A = 1 \text{ bar}$, $(p_B)_{\text{initial}} = 10 \text{ bar}$ and $(p'_B)_{\text{final}} = 100 \text{ bar}$

For reaction, $A \rightleftharpoons B$

$$K_{p_1} = \frac{p_B}{p_A} = \frac{10}{1} \text{ and } K_{p_2} = \frac{p'_B}{p_A} = \frac{100}{1}$$

At equilibrium, $\Delta G^\circ = -RT \ln K_p$

$$\Delta G_1^\circ = -RT_1 \ln K_{p_1} \quad \dots(i)$$

$$\Delta G_2^\circ = -RT_2 \ln K_{p_2} \quad \dots(ii)$$

On dividing equation (i) by (ii), we get

$$\frac{\Delta G_1^\circ}{\Delta G_2^\circ} = \frac{T_1}{T_2} \times \frac{\ln K_{p_1}}{\ln K_{p_2}}$$

$$= \frac{1000}{2000} \times \frac{\ln(10)}{\ln(100)} = \frac{1}{2} \times \frac{2.303}{2.303 \times 2} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = 0.25$$

20. (C)

For other sections/subjects please refer to
Physics For You and Biology Today

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LEVEL-I Exam on

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CLASS XII

SYLLABUS*

Section – 1 : Physics : Electricity and Magnetism, Electromagnetic Induction, Alternating current, Electromagnetic waves, Optics, Modern Physics, Semiconductor Electronics, Communication Systems.

Chemistry : The Solid State, Solutions, Electrochemistry, Chemical Kinetics, Surface Chemistry, General Principles and Processes of Isolation of Elements, The *p*-Block Elements (Group 15 to 18), The *d*- & *f*-Block Elements, Coordination Compounds, Haloalkanes and Haloarenes, Alcohols, Phenols and Ethers, Aldehydes, Ketones and Carboxylic Acids, Amines, Biomolecules, Polymers, Chemistry in Everyday Life.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section – 1.

Section – 3 : Relations and Functions, Inverse Trigonometric Functions, Matrices and Determinants, Continuity and Differentiability, Application of Derivatives, Integrals, Application of Integrals, Differential Equations, Vector Algebra, Three Dimensional Geometry, Probability, Linear Programming.

OR

Section – 3 : Reproduction, Genetics and Evolution, Biology in Human Welfare, Biotechnology, Ecology.

Total Questions : 50

Time : 1 hr.

PATTERN & MARKING SCHEME

Section	(1) Physics & Chemistry	(2) Achievers Section	(3) Mathematics or Biology
No. of Questions	25	5	20
Marks per Ques.	1	3	1

Practice Questions

- What will be the potential corresponding to the following cell?
 $\text{Pt} \mid \text{Co}^{2+}(2.0 \text{ M}), \text{Co}^{3+}(0.01 \text{ M}) \parallel \text{Cr}^{3+}(0.5 \text{ M}), \text{Cr}_2\text{O}_7^{2-}(4.0 \text{ M}), \text{H}^+(1.5 \text{ M}) \mid \text{Pt}$
 Given, $E^\circ_{\text{Co}^{2+} \mid \text{Co}^{3+}} = -1.82 \text{ V}$; $E^\circ_{\text{Cr}_2\text{O}_7^{2-} \mid \text{Cr}^{3+}} = +1.33 \text{ V}$
 A. -0.32 V B. -0.45 V
 C. $+0.56 \text{ V}$ D. $+0.39 \text{ V}$
- A solution containing 0.2563 g of naphthalene (molecular mass = 128) in 50 g of carbon tetrachloride yields a boiling point elevation of 0.201°C while a solution of 0.6216 g of an unknown solute in the same mass of the solvent gives a boiling point elevation of 0.647°C . The molecular mass of unknown solute is
 A. 85.45 g B. 100.23 g
 C. 91.25 g D. 96.44 g
- At 407 K, the rate constant of a chemical reaction is $9.5 \times 10^{-5} \text{ s}^{-1}$ and at 420 K, the rate constant is $1.9 \times 10^{-4} \text{ s}^{-1}$. The Arrhenius parameter of the reaction is
 A. $4.35 \times 10^{-2} \text{ s}^{-1}$ B. $6.08 \times 10^4 \text{ s}^{-1}$
 C. $5.04 \times 10^5 \text{ s}^{-1}$ D. $3.56 \times 10^5 \text{ s}^{-1}$
- A gaseous reaction $\text{A}_{2(g)} \rightarrow \text{B}_{(g)} + \frac{1}{2} \text{C}_{(g)}$ shows increase in pressure from 100 mm to 120 mm in 5 min. What is the rate of disappearance of A_2 in mm min^{-1} ?
 A. 6 B. 8 C. 10 D. 7
- Select the incorrect statement.
 A. An acidified solution of $\text{K}_2\text{Cr}_2\text{O}_7$ liberates iodine from iodides.
 B. In acidic solution, dichromate ions are converted to chromate ions.
 C. Ammonium dichromate on heating undergo exothermic decomposition to give Cr_2O_3 .
 D. Potassium dichromate is used as a titrant for Fe^{2+} ions.
- Which of the following statements are incorrect?
 I. Metal carbonyls are the examples of only σ -bonded organometallic complexes.
 II. Metal carbonyls are the examples of only π -bonded organometallic complexes.
 III. Metal carbonyls are the examples of organometallic complexes which involve both σ and π -bonds between metal and carbon of the carbonyl group.

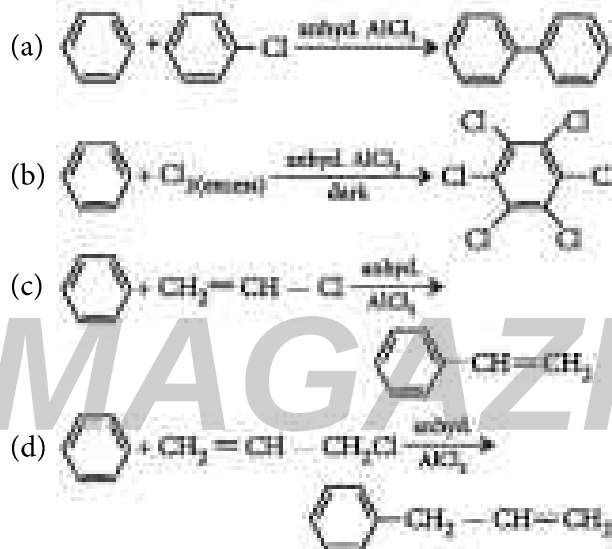
IV. Metal carbonyls involve both σ - and π -bonds between metal and oxygen of the carbonyl group.

- A. I, II and IV only B. II and III only
C. I and III only D. II, III and IV only

7. In which of the following pairs, both the complexes show optical isomerism?

- A. $\text{cis}[\text{Cr}(\text{C}_2\text{O}_4)_2\text{Cl}_2]^{3-}$, $\text{cis}[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$
B. $[\text{Co}(\text{en})_3]\text{Cl}_3$, $\text{cis}[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$
C. $[\text{Co}(\text{NO}_3)_3(\text{NH}_3)_3]$, $\text{cis}[\text{Pt}(\text{en})_2\text{Cl}_2]$
D. $[\text{PtCl}(\text{en})\text{Cl}]$, $[\text{NiCl}_2\text{Br}_2]^{2-}$

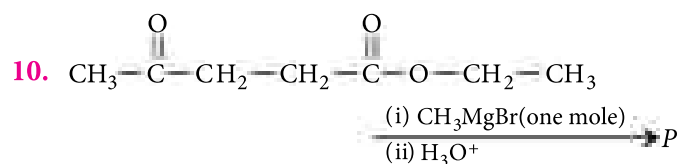
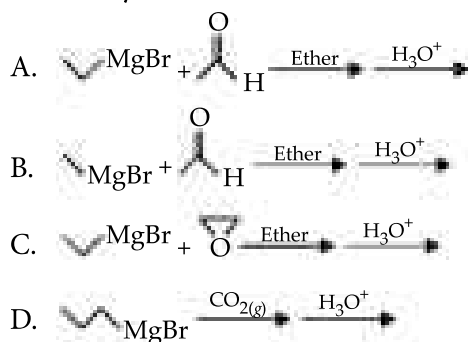
8. Consider the following reactions.



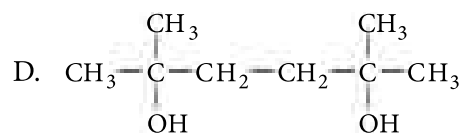
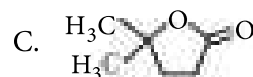
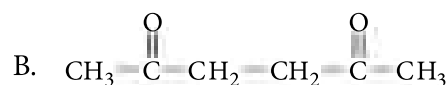
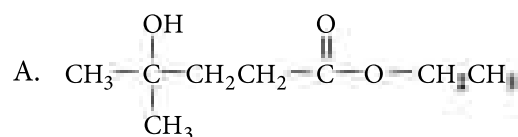
Which of these reactions are possible?

- A. (a) and (b) B. (b) and (d)
C. (a) and (d) D. (b), (c) and (d)

9. Which of the following reactions would provide the best synthesis of butan-2-ol?



'P' formed in this reaction is



11. The correct order of basic strength in aqueous solution is

- A. $(\text{CH}_3)_2\text{NH} > \text{CH}_3\text{NH}_2 > (\text{CH}_3)_3\text{N}$
B. $(\text{CH}_3)_3\text{N} > (\text{CH}_3)_2\text{NH} > \text{CH}_3\text{NH}_2$
C. $\text{CH}_3\text{NH}_2 > (\text{CH}_3)_3\text{N} > (\text{CH}_3)_2\text{NH}$
D. $(\text{CH}_3)_3\text{N} > \text{CH}_3\text{NH}_2 > (\text{CH}_3)_2\text{NH}$

12. What is the correct explanation of the non-reducing property of sucrose?

- A. α -D-glucopyranose and β -D-fructofuranose are linked *via* C_2 and C_1 centres respectively.
B. α -D-glucopyranose and β -D-fructofuranose are linked *via* C_1 and C_2 centres respectively.
C. α -D-glucopyranose and β -D-fructofuranose are linked *via* C_2 and C_3 centres respectively.
D. α -D-glucopyranose and β -D-fructofuranose are linked *via* C_3 and C_4 centres respectively.

NSO

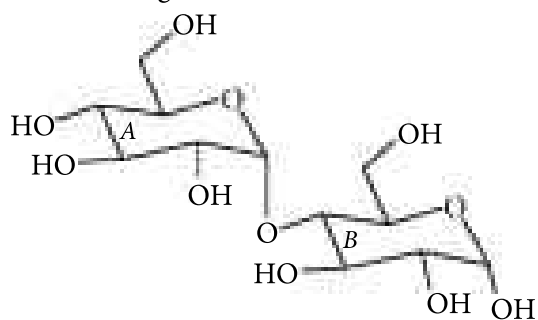
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CLASS 12



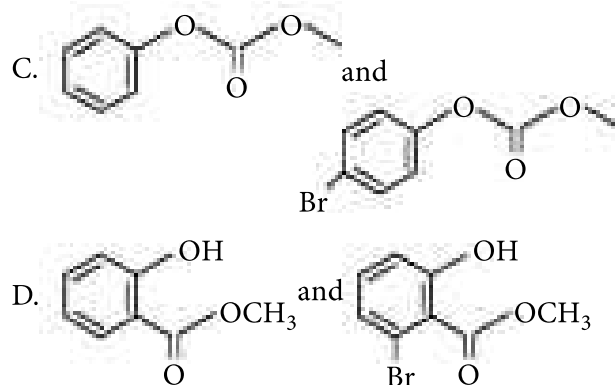
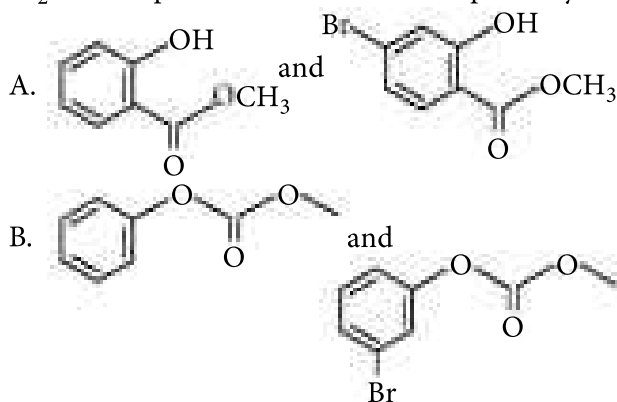
13. In the following disaccharide,



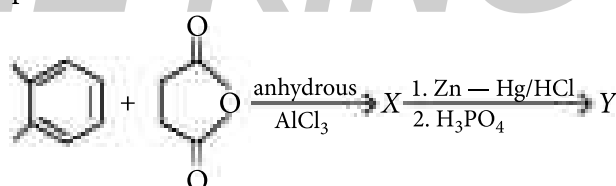
- A. ring (A) is pyranose with α -glycosidic link
 B. ring (A) is furanose with α -glycosidic link
 C. ring (B) is pyranose with β -glycosidic link
 D. ring (B) is furanose with α -glycosidic link.
14. For the disproportionation reaction,
 $2\text{Cu}^+_{(aq)} \rightleftharpoons \text{Cu}_{(s)} + \text{Cu}^{2+}_{(aq)}$ at 298 K. In K_c (where K_c is the equilibrium constant) is $\times 10^{-1}$.
 Given :
 $\left(E^\circ_{\text{Cu}^{2+}/\text{Cu}^+} = 0.16 \text{ V}; E^\circ_{\text{Cu}^+/\text{Cu}} = 0.52 \text{ V}; \frac{RT}{F} = 0.025 \right)$
 A. 138 B. 144 C. 156 D. 140
15. A binary liquid solution is prepared by mixing *n*-heptane and ethanol. Which one of the following statements is correct regarding the behaviour of the solution?
 A. The solution formed is an ideal solution.
 B. The solution is non-ideal, showing positive deviation from Raoult's law.
 C. The solution is non-ideal, showing negative deviation from Raoult's law.
 D. *n*-heptane shows positive deviation while ethanol shows negative deviation from Raoult's law.

ACHIEVERS SECTION

16. Phenol reacts with methyl chloroformate in the presence of NaOH to form product A. A reacts with Br_2 to form product B. A and B are respectively

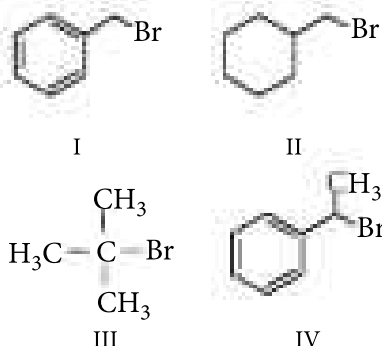


17. The correct statements regarding the complex $[\text{Co}(\text{en})(\text{NH}_3)_3(\text{H}_2\text{O})]^{3+}$ ($\text{en} = \text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$) are
 I. It has two geometrical isomers.
 II. It will have three geometrical isomers if bidentate 'en' is replaced by two cyanide ligands.
 III. It is paramagnetic.
 IV. It absorbs light at longer wavelength as compared to $[\text{Co}(\text{en})(\text{NH}_3)_4]^{3+}$.
 A. I, III and IV only B. III and IV only
 C. I, II and IV only D. II and III only
18. In the following reaction sequence, the major products X and Y are



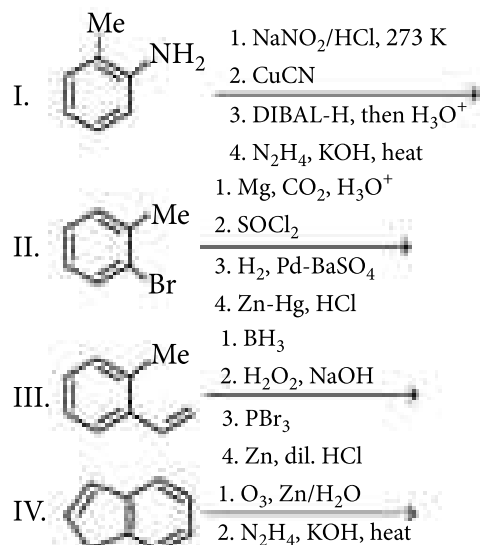
- A. $X = \text{C}_6\text{H}_5\text{CO}_2\text{H}$; $Y = \text{C}_6\text{H}_5\text{CO}_2\text{H}$
- B. $X = \text{C}_6\text{H}_5\text{CO}_2\text{H}$; $Y = \text{C}_6\text{H}_5\text{CO}_2\text{H}$
- C. $X = \text{C}_6\text{H}_5\text{CO}_2\text{H}$; $Y = \text{C}_6\text{H}_5\text{CO}_2\text{H}$
- D. $X = \text{C}_6\text{H}_5\text{CO}_2\text{H}$; $Y = \text{C}_6\text{H}_5\text{CO}_2\text{H}$

19. For the following compounds, the incorrect statement with respect to nucleophilic substitution reactions is



- A. I and II follow S_N2 mechanism.
 B. compound IV undergoes inversion of configuration.
 C. the order of reactivity for I, III, and IV is :
 $III > I > IV$.
 D. I and III follow S_N1 mechanism.

20. The reaction sequences that would lead to *o*-xylene as the major product are



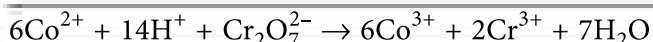
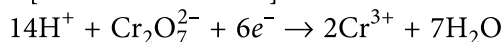
- A. I and III only B. I and II only
 C. II and IV only D. III and IV only

Darken your choice with HB Pencil

1. ☐ A ☐ B ☐ C ☐ D	5. ☐ A ☐ B ☐ C ☐ D	9. ☐ A ☐ B ☐ C ☐ D	13. ☐ A ☐ B ☐ C ☐ D	17. ☐ A ☐ B ☐ C ☐ D
2. ☐ A ☐ B ☐ C ☐ D	6. ☐ A ☐ B ☐ C ☐ D	10. ☐ A ☐ B ☐ C ☐ D	14. ☐ A ☐ B ☐ C ☐ D	18. ☐ A ☐ B ☐ C ☐ D
3. ☐ A ☐ B ☐ C ☐ D	7. ☐ A ☐ B ☐ C ☐ D	11. ☐ A ☐ B ☐ C ☐ D	15. ☐ A ☐ B ☐ C ☐ D	19. ☐ A ☐ B ☐ C ☐ D
4. ☐ A ☐ B ☐ C ☐ D	8. ☐ A ☐ B ☐ C ☐ D	12. ☐ A ☐ B ☐ C ☐ D	16. ☐ A ☐ B ☐ C ☐ D	20. ☐ A ☐ B ☐ C ☐ D

SOLUTIONS

1. (A) : $[\text{Co}^{2+} \rightarrow \text{Co}^{3+} + e^-] \times 6$



$$E_{\text{cell}}^\circ = -1.82 + 1.33 \text{ V} = -0.49 \text{ V}$$

$$E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{0.0591}{6} \log \frac{[\text{Co}^{3+}]^6 [\text{Cr}^{3+}]^2}{[\text{Co}^{2+}]^6 [\text{Cr}_2\text{O}_7^{2-}] [\text{H}^+]^{14}}$$

$$= -0.49 - \frac{0.0591}{6} \log \frac{[10^{-2}]^6 [0.50]^2}{[2.0]^6 [4.0] [1.5]^{14}} = -0.32 \text{ V}$$

2. (D) : We know that, $K_b = \frac{\Delta T_b \times W_1 \times MW_2}{1000 \times W_2}$

$$\text{For } \text{CCl}_4; K_b = \frac{0.201 \times 50 \times 128}{1000 \times 0.2563} = 5.019$$

$$MW_2 = \frac{1000 \times K_b \times W_2}{\Delta T_b \times W_1} = \frac{1000 \times 5.019 \times 0.6216}{0.647 \times 50} = 96.44 \text{ g}$$

3. (C) : The Arrhenius equation is,

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303R} \left[\frac{T_2 - T_1}{T_1 T_2} \right]$$

Given : $k_1 = 9.5 \times 10^{-5} \text{ s}^{-1}$; $k_2 = 1.9 \times 10^{-4} \text{ s}^{-1}$;
 $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$; $T_1 = 407 \text{ K}$ and $T_2 = 420 \text{ K}$

Substituting the values in Arrhenius equation, we get

$$\log \left(\frac{1.9 \times 10^{-4}}{9.5 \times 10^{-5}} \right) = \frac{E_a}{2.303 \times 8.314} \left(\frac{420 - 407}{420 \times 407} \right)$$

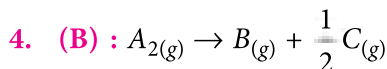
$$E_a = 75782.8 \text{ J mol}^{-1}$$

$$\text{Applying now, } \log k_1 = \log A - \frac{E_a}{2.303 RT_1}$$

$$\log (9.5 \times 10^{-5}) = \log A - \frac{75782.8}{2.303 \times 8.314 \times 407}$$

$$\text{or } \log \frac{A}{9.5 \times 10^{-5}} = \frac{75782.8}{2.303 \times 8.314 \times 407} = 9.7246$$

$$A = 5.04 \times 10^5 \text{ s}^{-1}$$



Initial	P	0	0
At eq.	$P - x$	x	$x/2$

$$\text{Total pressure} = P - x + x + x/2 = P + x/2$$

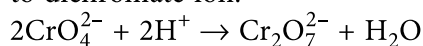
$$\text{Initial pressure (P)} = 100 \text{ mm}$$

$$\text{Final pressure} = \text{Total pressure} = 120 \text{ mm}$$

$$\therefore P + x/2 = 120 ; 100 + x/2 = 120 ; x = 40 \text{ mm}$$

$$\therefore \frac{-d[A_2]}{dt} = \frac{40}{5} = 8 \text{ mm min}^{-1}$$

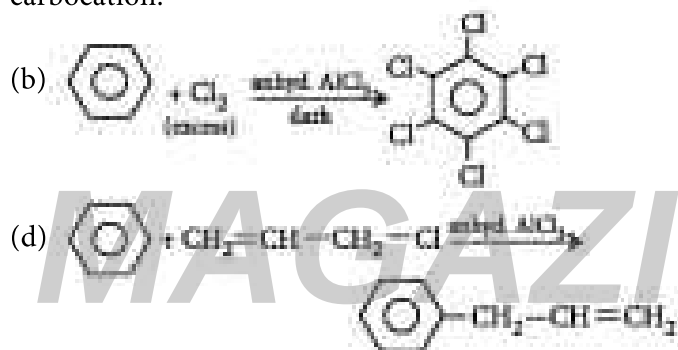
5. (B) : In acidic solution, chromate ions are converted to dichromate ion.



6. (A) : Metal carbonyls are the examples of organometallic complexes which involve both σ and π bonds between metal and carbon of the carbonyl group. Thus, statement, I, II and IV are incorrect.

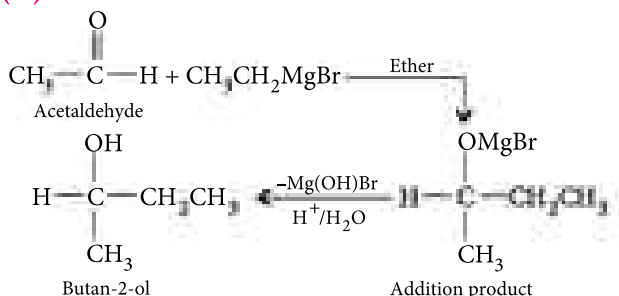
7. (B) : Both $[\text{Co}(\text{en})_3\text{Cl}_3]$ and *cis* $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ are optically active. *cis* $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ has two non-superimposable mirror images, hence is optically active. While $[\text{Co}(\text{en})_3\text{Cl}_3]$ also shows optical isomerism. It will have two optical isomers, dextrorotatory and laevorotatory.

8. (B) : Aryl halide (a) and vinyl halide (c) do not give Friedel – Crafts reaction due to formation of unstable carbocation.

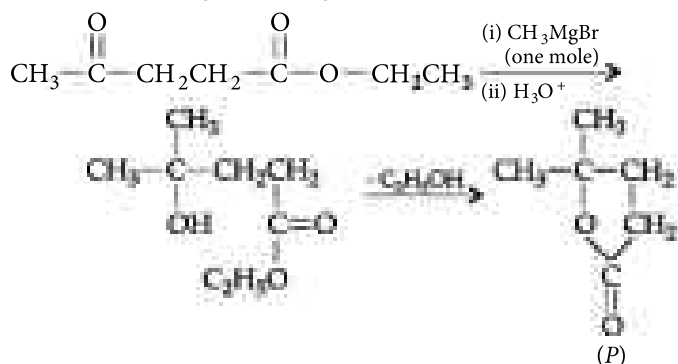


Thus, (b) and (d) are possible reactions.

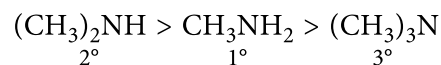
9. (A) :



10. (C) : Keto group is more reactive than ester for addition of Grignard reagent.



11. (A) : The basicity of amines in aqueous solution primarily depend upon the +I effect of alkyl groups, extent of H-bonding with water molecules and steric effect of the alkyl groups. When the alkyl group is small, like $-\text{CH}_3$ group, there is no steric hindrance to H-bonding. Hence, the order of basic strength in case of methyl substituted amines in aqueous solution is :



12. (B) : Sucrose is a non-reducing sugar since, both glucose ($\text{C}_1 - \alpha$) and fructose ($\text{C}_2 - \beta$) are connected to each other through their reducing centres.

13. (A)

14. (B) : For reaction, $2\text{Cu}^+_{(\text{aq})} \rightleftharpoons \text{Cu}_{(\text{s})} + \text{Cu}^{2+}_{(\text{aq})}$

$$E^\circ_{\text{cell}} = \frac{RT}{nF} \ln K_c$$

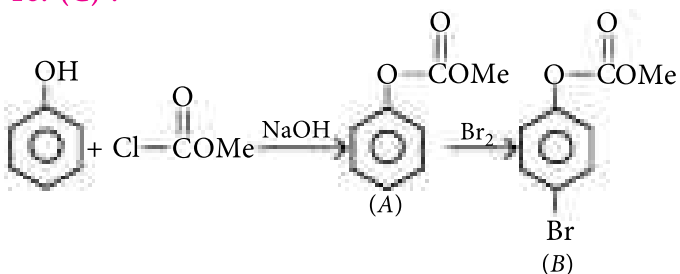
$$E^\circ_{\text{cell}} = E^\circ_{\text{Cu}^+/\text{Cu}} - E^\circ_{\text{Cu}^{2+}/\text{Cu}^+} = 0.52 - 0.16 = 0.36 \text{ V}$$

$$0.36 \text{ V} = \frac{0.025}{1} \ln K_c \quad (n = 1)$$

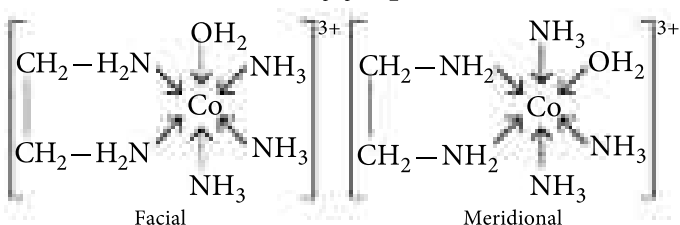
$$\ln K_c = \frac{0.36}{0.025} = 14.4 = 144 \times 10^{-1}$$

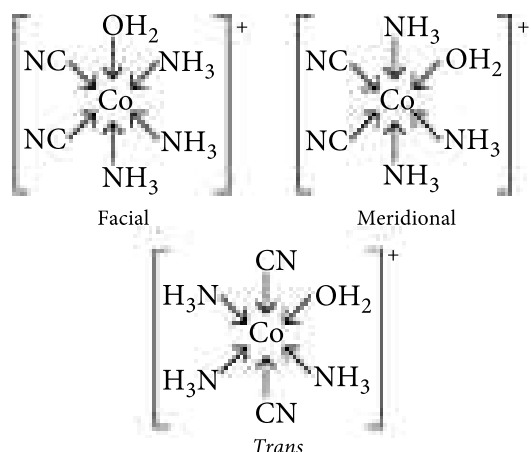
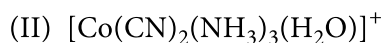
15. (B) : The solution containing *n*-heptane and ethanol shows non-ideal behaviour with positive deviation from Raoult's law. This is because the ethanol molecules are held together by strong H-bonds, however the forces between *n*-heptane and ethanol are not very strong, as a result they easily vapourise showing higher vapour pressure than expected.

16. (C) :



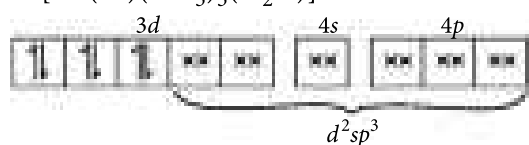
17. (C) : (I) $[\text{Co}(\text{en})(\text{NH}_3)_3(\text{H}_2\text{O})]^{3+}$





(III) $\text{Co}^{3+} : [\text{Ar}]3d^6$ in presence of *en* and NH_3 , it forms a low spin complex.

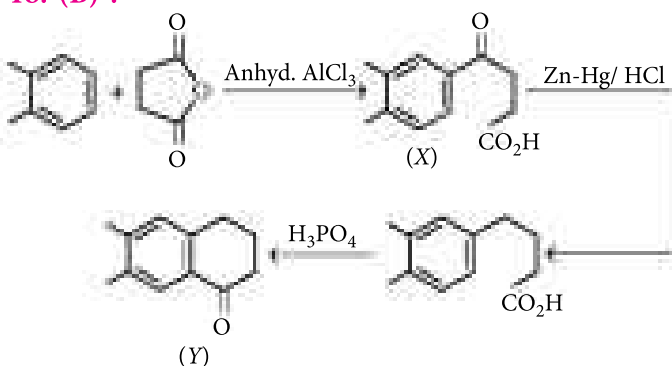
Co^{3+} in $[\text{Co}(\text{en})(\text{NH}_3)_3(\text{H}_2\text{O})]^{3+}$:



Due to absence of unpaired electron, this complex is diamagnetic in nature.

(IV) $[\text{Co}(\text{en})(\text{NH}_3)_4]^{3+}$ has larger energy gap between t_{2g} and e_g orbitals than $[\text{Co}(\text{en})(\text{NH}_3)_3(\text{H}_2\text{O})]^{3+}$, as NH_3 is a stronger ligand than H_2O . So, $[\text{Co}(\text{en})(\text{NH}_3)_3(\text{H}_2\text{O})]^{3+}$ absorbs longer wavelength than $[\text{Co}(\text{en})(\text{NH}_3)_4]^{3+}$.

18. (B) :



19. (C) : (a) Compounds I and II are 1° alkyl halides, thus they undergo nucleophilic substitution *via* $\text{S}_{\text{N}}2$ mechanism.

(b) Compound IV undergoes inversion of configuration due to intimate-ion pair formation, inversion predominates over retention.

(c) Stability of carbocations follows the order :

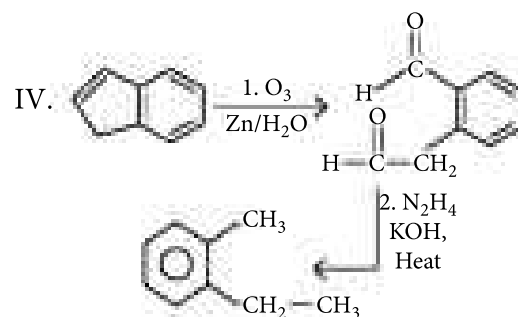
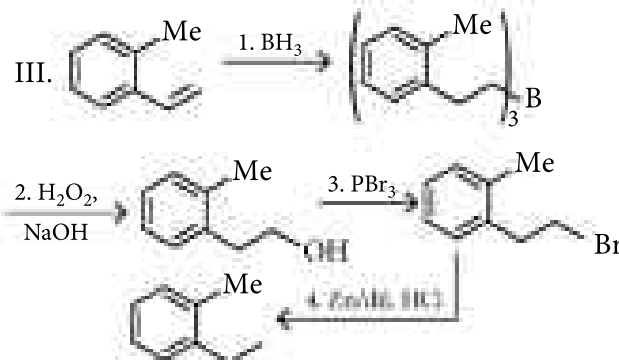
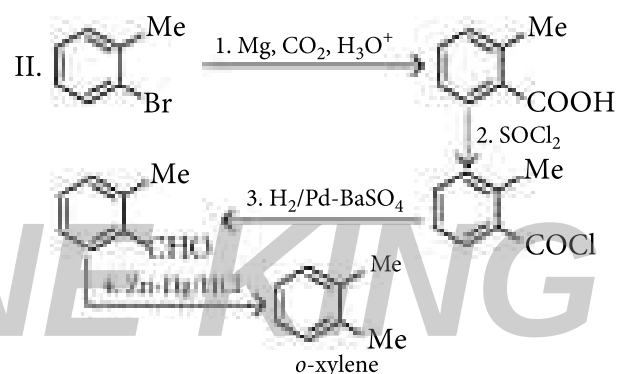
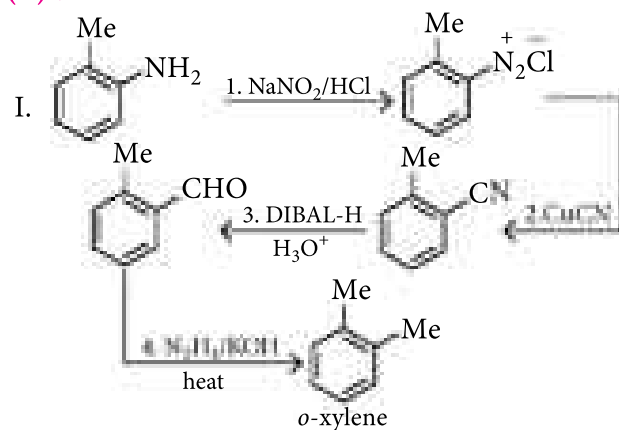
2° benzylic $>$ 3° alkyl $>$ 1° benzylic

(IV) (III) (I)

(d) I is a benzylic halide, thus, it undergoes $\text{S}_{\text{N}}1$ reaction easily as benzylic carbocation is resonance

stabilised. III also follows $\text{S}_{\text{N}}1$ mechanism as it a 3° alkyl halide.

20. (B) :



For other sections/subjects please refer to
Physics For You and Biology Today

FOCUS

TOPIC**Extraction of Metals**

Detailed theory with High Definition images of the given topic is covered under this heading.

The whole process of obtaining a pure metal from one of its ores is known as **metallurgy**. In order to extract the metals from ores, several physical and chemical methods are used. The method used in a particular case depends upon the nature of the ore, the properties of the metal and other conditions. Thus, it is not possible to have a universal method for the extraction of all the metals from their ores. However, the metallurgy of a metal involves three main operations :

- (i) Concentration or dressing of the ore.
- (ii) Isolation of the metal in crude state from the concentrated ore.
- (iii) Purification or refining of the crude metal.

Methods for Concentration of the Ore

Handpicking

Hydraulic washing

Froth floatation

Leaching

Now, let us discuss the extraction of crude metals from their concentrated ores.

Extraction of Crude Metals

The process used to obtain metals in free state from concentrated ores is called **extraction**. Since many metals can be easily obtained from their respective oxides by reduction (electronation), therefore, the extraction of metals actually involves the following two chemical processes :

- Conversion of the ore into metal oxide, *i.e.*, de-electronation of ore.
- Reduction or electronation of the metal oxide to the free metal.

Factors influencing the choice of extraction process :

The type of process used commercially for any particular element (metal) depends on a number of factors :

Is the element unreactive enough to exist in the free state?

Are any of the compounds unstable to heat?

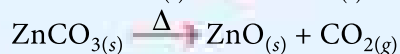
Does the element exist as an ionic compound, and is the element stable in its aqueous solution?

Does the element occur as sulphide ore which can be roasted, or oxide ore which can be reduced by carbon (which can be cheaper) or by Al, Mg and Na (which can be costlier)?

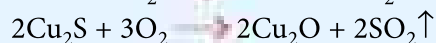
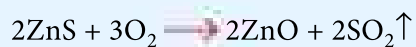
Conversion of the Ore into Metal Oxide

Metals are usually present in ores as hydrated oxides (hydroxides), carbonates and sulphides. Depending upon the nature of the minerals present in the ores, the following two methods are used for conversion of ores into their respective oxides :

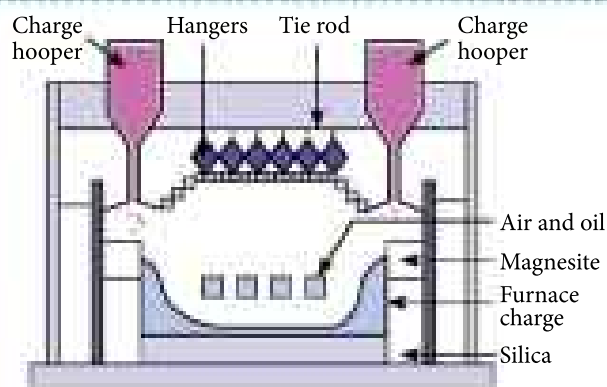
- **Calcination** involves heating of the ore below its fusion temperature in absence of air. This step expels organic matter and moisture from the ores and is mainly used to convert carbonates and hydrated oxide ores to their respective oxides.



- **Roasting** involves heating of the ore in presence of oxygen below its fusion temperature and is generally used to convert sulphide ores into their oxides.



The sulphide ores of copper are heated in a reverberatory furnace as shown in figure.



A section of a modern reverberatory furnace

Reduction of Metal Oxide to the Free Metal

The reduction of metal oxide to the free metal is done by using a suitable reducing agent, following methods can be applied :

Smelting

The process of extracting a metal by heating the metal oxide with carbon (in the form of coke, charcoal or carbon monoxide).



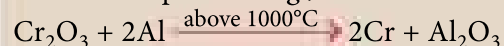
Pyrometallurgy

The process of extracting the metal by heating the metal oxide with a suitable reducing agent such as C, H₂, CO, water gas, Na, K, Mg, Al, etc.

Goldschmidt aluminothermic process – Reduction by aluminium

This process is used in the case of those metals which have very high melting points and are to be extracted from their oxides.

The process in which aluminium metal is used as reducing agent for the extraction of less electropositive metals like Fe, Mn, Cr, etc. from their oxides is known as Goldschmidt process or thermite process. *e.g.*,



Various other methods like, self-reduction, electrolytic reduction and hydrometallurgy are also used for the reduction of metal oxides to free metals.

Extraction of Iron from Haematite

Iron is usually extracted from the oxide ore, *i.e.*, haematite. The extraction of iron involves the following steps :

Concentration

The ore is crushed in jaw crushers and the crushed ore is concentrated by gravity separation process in which the crushed ore is washed in a stream of water when lighter sand and clay particles are washed away while the heavier ore particles settle down.



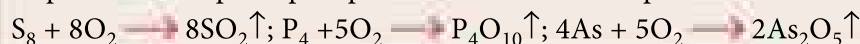
Haematite Ore

Calcination

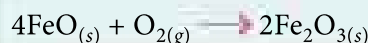
The concentrated ore is then calcinated in a reverberatory furnace. During calcination of the concentrated ore, the following changes take place :

Moisture is removed.

Impurities of sulphur, phosphorus and arsenic escape as their volatile oxides.



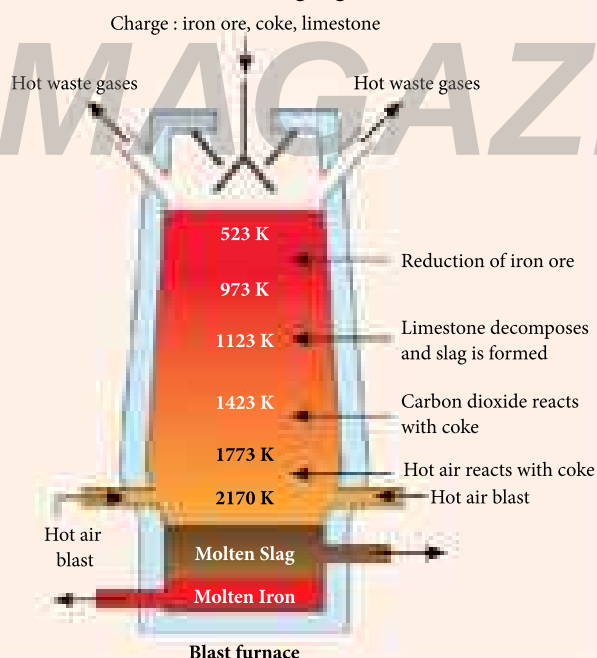
Ferrous oxide is oxidised to ferric oxide, thereby preventing the loss of iron as slag during smelting.



The ore becomes porous and hence is more suitable for reduction to the metallic state.

Smelting

The calcined ore is then smelted in a blast furnace as shown in the following figure :



Reactions taking place in the furnace

The following reactions occur in the blast furnace :

Zone of combustion : Near the tuyeres, coke burns to form carbon dioxide.



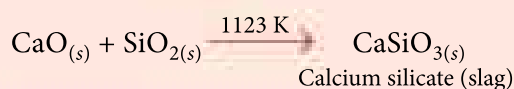
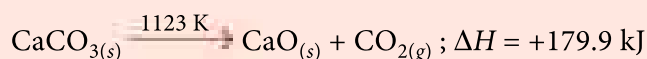
As the reaction is exothermic, lot of heat is produced and the temperature here is around 2170 K.

Zone of heat absorption : This is lower part of the furnace and the temperature here is between 1423-1673 K. As CO_2 formed near tuyeres moves up, it meets the descending charge. The coke present in the charge reduces CO_2 to CO.



Since this reaction is endothermic, therefore, the temperature gradually falls to 1423 K.

Zone of slag formation : It is the middle part of the furnace and the temperature here is around 1123 K. In this region, limestone decomposes to form CaO and CO_2 . The CaO thus formed acts as a flux and combines with silica (present as an impurity) to form fusible calcium silicate slag.



CONCEPT MAP

General Principles

MODES OF OCCURRENCE OF ELEMENTS

The naturally occurring materials in which metals or their compounds occur in the earth's crust are called minerals. Those minerals from which the metals may be extracted conveniently and economically are called ores.

All ores are minerals but all minerals are not ores.

Combined State

Elements which easily react with oxygen, moisture and other chemical reagents occur in the combined state, i.e., in the form of their compounds. In the combined state, non-metals occur in the reduced form, i.e., X^- (where $X^- = F^-, Cl^-, Br^-$, etc.), whereas metals occur in the oxidised form (i.e., oxides (e.g., Al_2O_3 , Fe_2O_3 , etc.))



Native State

When an element is found in free or in uncombined state, it is said to occur in native state. These elements have little or no affinity for oxygen and resist the attack of water and other chemical reagents. Some elements found in the native state are copper (Cu), silver (Ag), gold (Au), platinum (Pt) etc.

METALLURGY

The entire scientific and technological process used for isolation of the metal from its ore is known as metallurgy.

Refining of Crude Metals

Crushing and Grinding

Ore lumps are crushed to smaller pieces by hammering or by help of a jaw-crusher. The crushed ore is then finally converted to fine powdered state. This process of converting crushed ore into fine powdered state is called pulverisation.

Extraction of Metal from Concentrated Ore

Concentration or Benefaction of Ore

- **Hand picking** : When impurities present are of large size, these may be removed by hand picking.
- **Gravity or levigation separation or hydraulic washing** : This method is used when the ore particles are heavier than the gangue particles. The ore is washed with a spray of water so that lighter impurities are washed away and heavier ore particles settle down.
- **Froth floatation process** : Powdered ore is mixed with water and a little pine oil and the mixture is vigorously stirred by passing compressed air. The froth, which is produced rises to the surface and carries the ore particles along with it. The gangue is left behind. This process is used for concentrating sulphide ores.
- **Electromagnetic separation** : This process of separation is used when either ore or impurities are magnetic in nature.
- **Leaching process** : In this method, the ore is treated chemically with a suitable reagent, that preferentially dissolves the ore particles while impurities remain insoluble. Impurities are filtered out and ore is recovered from the solution by a suitable chemical method.



Reduction of Metal Oxide to Metal

- **Chemical reduction** : Chemical reduction usually involves the reduction of metal ions in some type of solvent and a separate reducing agent.
- **Auto-reduction** : The metal is obtained either by direct roasting or by the reduction of its partially oxidised form.
- **Aluminothermic reduction** : In this process, a large amount of heat is evolved so that metal is obtained in liquid state. Molten metal produced as a result of thermite process can be used in weld parts of heavy articles like girders, railway track, etc.
- **Smelting** : Reduction by carbon (as coal, coke, charcoal, C).
- **Displacement method** : Some metals are reduced by displacement by a more reactive metal, from the complexes.
- **Electrolytic method** : Used for highly electropositive elements of groups 1 and 2, which are found as the chlorides or oxosalts (converted to chlorides later) and their electrolysis is done in fused or molten form. The metal ions are deposited at negative electrode (cathode).

and Processes of Isolation of Elements

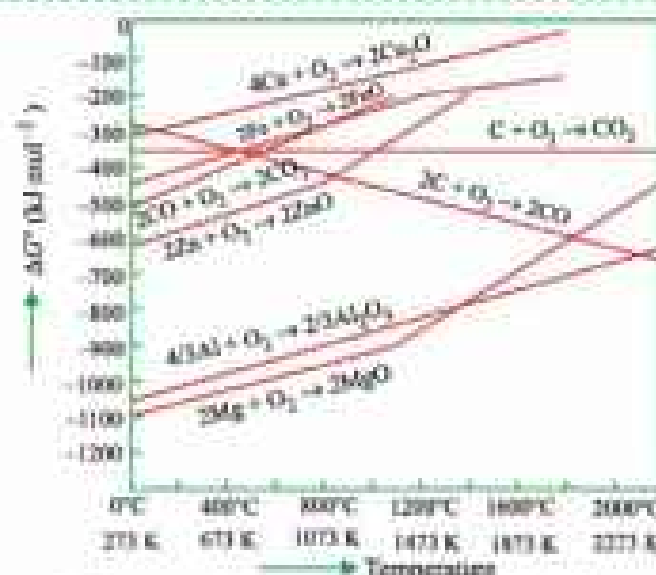
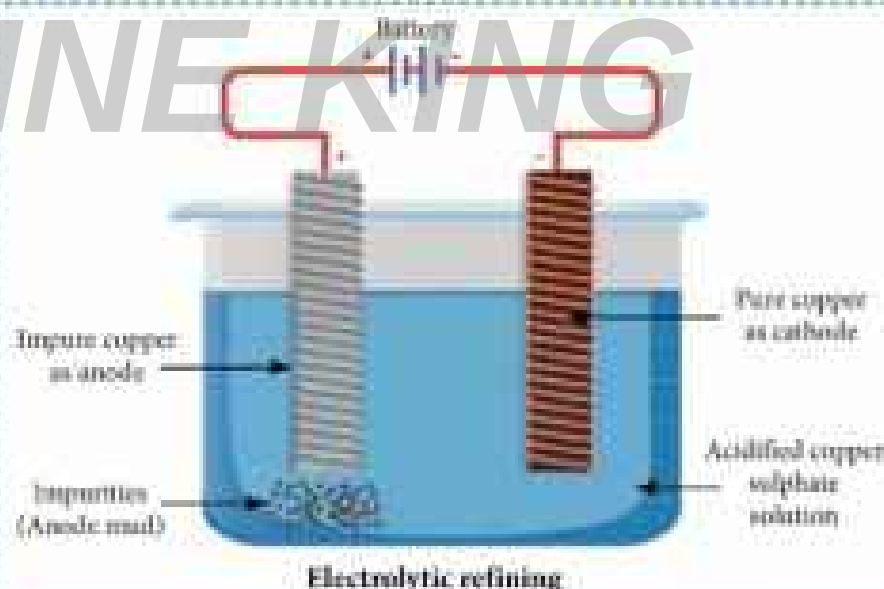
Methods	Metals purified
1. Distillation	In this method, the impure metal is heated above its boiling point, so that it can form vapours. The impurities do not vapourise and thus, they are separated. Used for highly volatile metals like Zn, Cd, Hg, etc.
2. Liquation	Impure metal can be made to flow on a sloping surface and thus separated from impurities having higher melting point (less fusible). Used for metals like Sn, Bi, Pb, Hg, etc.
3. Zone refining	Metals of high purity are obtained by this method. Silicon, germanium, boron, gallium and indium are purified (which are used in semiconductors). It is based on the fact that impurities are more soluble in the molten form than in the solid state of the metal.
4. Vapour phase refining	In this method, the crude metal is freed from impurities by first converting it into a suitable volatile compound by heating it with a specific reagent at a lower temperature and then decomposing the volatile compound at some higher temperature to give the pure metal. Metals like nickel, titanium and zirconium are refined using this method.
5. Oxidation	This process is used when impurities have greater affinity for oxygen than metal itself and thus oxidised more readily. The impurities in the form of volatile oxides escape out.
6. Cupellation	This process is used when crude metal contains impurities of other metal which form volatile oxides. Impurities are oxidised to volatile products and removed. Silver can be purified by this method.
7. Electrolytic refining	Impure metal is made anode and the pure metal is made cathode. The net result is the transfer of pure metal from anode to cathode. This method is used for copper, gold, silver, lead and aluminium.

Conversion of Concentrated Ore to Oxide form

- **Calcination** : Commonly used for conversion of hydroxide or carbonate ores to oxides. It involves heating of the ore below its fusion temperature in absence of air in a reverberatory furnace.
- **Roasting** : Sulphide ores convert into oxides or when heated in a regular supply of air at a temperature below the melting point of the metal.

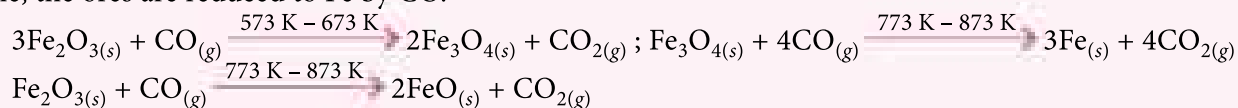
Thermodynamic Principles of Metallurgy

The plots between $\Delta_r G^\circ$ of oxides of elements vs. temperature are called Ellingham diagrams. They provide a sound idea about selecting a reducing agent for reduction of oxides. These diagrams help in predicting the feasibility of thermal reduction of an ore.

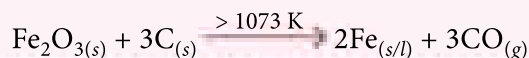


Gibbs energy (ΔG°) vs. T plots (schematic) for formation of some oxides per mole of oxygen consumed (Ellingham diagram)

Zone of reduction : This is the upper part of the furnace. The temperature here is between 500-900 K. In this zone, the ores are reduced to Fe by CO.



In the middle part of the furnace, the temperature is between 900 - 1500 K. Further, direct reduction of iron ores, (*i.e.*, haematite, magnetite, etc.), left unreduced around 873 K, occurs completely to iron by carbon above 1073 K.



Zone of fusion : This is the lower part of the furnace and the temperature here lies between 1423-1673 K. In this region, spongy iron melts and dissolves some C, S*, P*, Si*, Mn, etc. CaSiO₃ slag also melts in this region. Both the molten slag and the molten iron trickle down into hearth where they form two separate layers. The molten CaSiO₃ slag being lighter forms the upper layer while molten iron being heavier forms the lower layer. The two liquids are periodically tapped off. The iron thus obtained from the furnace contains about 4% carbon and many impurities (*e.g.*, S, P, Si, Mn) in smaller amount. This is called pig iron and is cast into variety of shapes.



Pig Iron

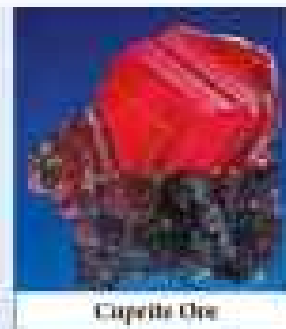
S*, P* and Si* are formed from sulphates, phosphates and silicates respectively present in the ore by reduction with carbon (C).

Extraction of Copper from Cuprite

Only a few ores of copper are oxide ores, and one among them is the cuprite or the cuprous oxide. In the Ellingham diagram, it is observed that (Cu, Cu₂O) curve is almost at the top, while the (C, CO) and (CO, CO₂) lines lie much below it mainly in the temperature range 500-600 K. The sulphide ores are first roasted in a reverberatory furnace to convert them into oxides.



The oxides can then be reduced to metallic copper using coke as the reducing agent.

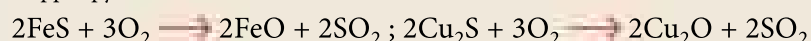


Cuprite Ore

In actual process, the sulphide ore (*i.e.*, copper pyrites), after concentration by froth floatation process is roasted in a reverberatory furnace when copper pyrites is converted into a mixture of FeS and Cu₂S, which, in turn, are partially oxidised.



Copper pyrites



Since iron is more reactive than copper, FeS is preferentially oxidised to FeO than Cu₂S to Cu₂O. If at all any Cu₂O is formed, it combines with FeS and is changed back to Cu₂S.



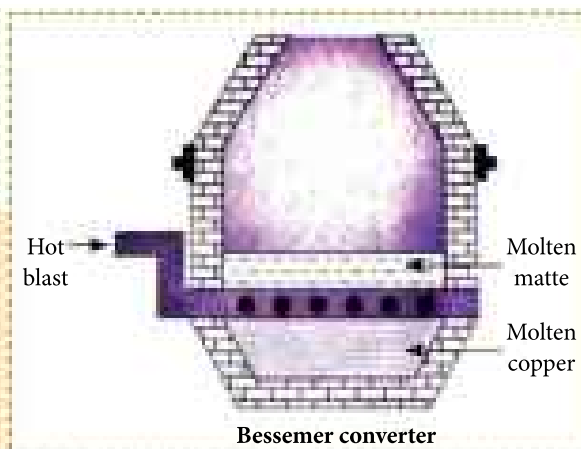
Thus, the roasted ore mainly contains Cu_2S and FeO along with some unreacted FeS .

- The roasted ore is then mixed with silica (flux) and some powdered coke (to check the oxidation of FeO to Fe_2O_3) and heated strongly in a blast furnace, in the process, called smelting. During smelting, FeO combines with silica to form fusible ferrous silicate slag.
- At the temperature of the furnace, the entire mass melts and two layers of molten mass are formed. The slag being lighter makes the upper layer, which can be withdrawn from the slag hole from time to time. The lower molten layer is called copper matte that chiefly consists of Cu_2S and some unchanged FeS .

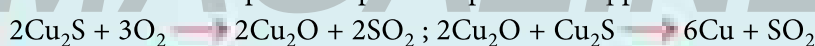
Recovery of copper from matte

The molten matte is transferred to a Bessemer converter, which is a pear-shaped furnace made of steel and lined inside with silica.

During the process of Bessemerisation, any sulphur, arsenic and antimony still present as impurity in matte escape as their respective volatile oxides while FeS is oxidised to FeO , which combines with silica to form FeSiO_3 as slag.



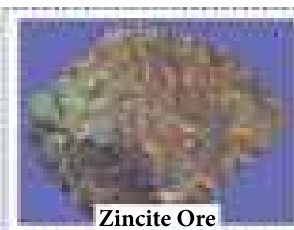
The slag thus formed melts and floats on the top of the molten mass and is removed. When whole of iron has been removed as slag, some of the cuprous sulphide undergoes oxidation to form cuprous oxide, which then reacts with cuprous sulphide to produce copper metal.



Copper metal so produced falls below tuyeres and thus escapes the oxidising action of the blast. After the completion of the reaction, the converter is tilted and the molten metal is poured in sand moulds. As the metal cools, dissolved SO_2 escapes.

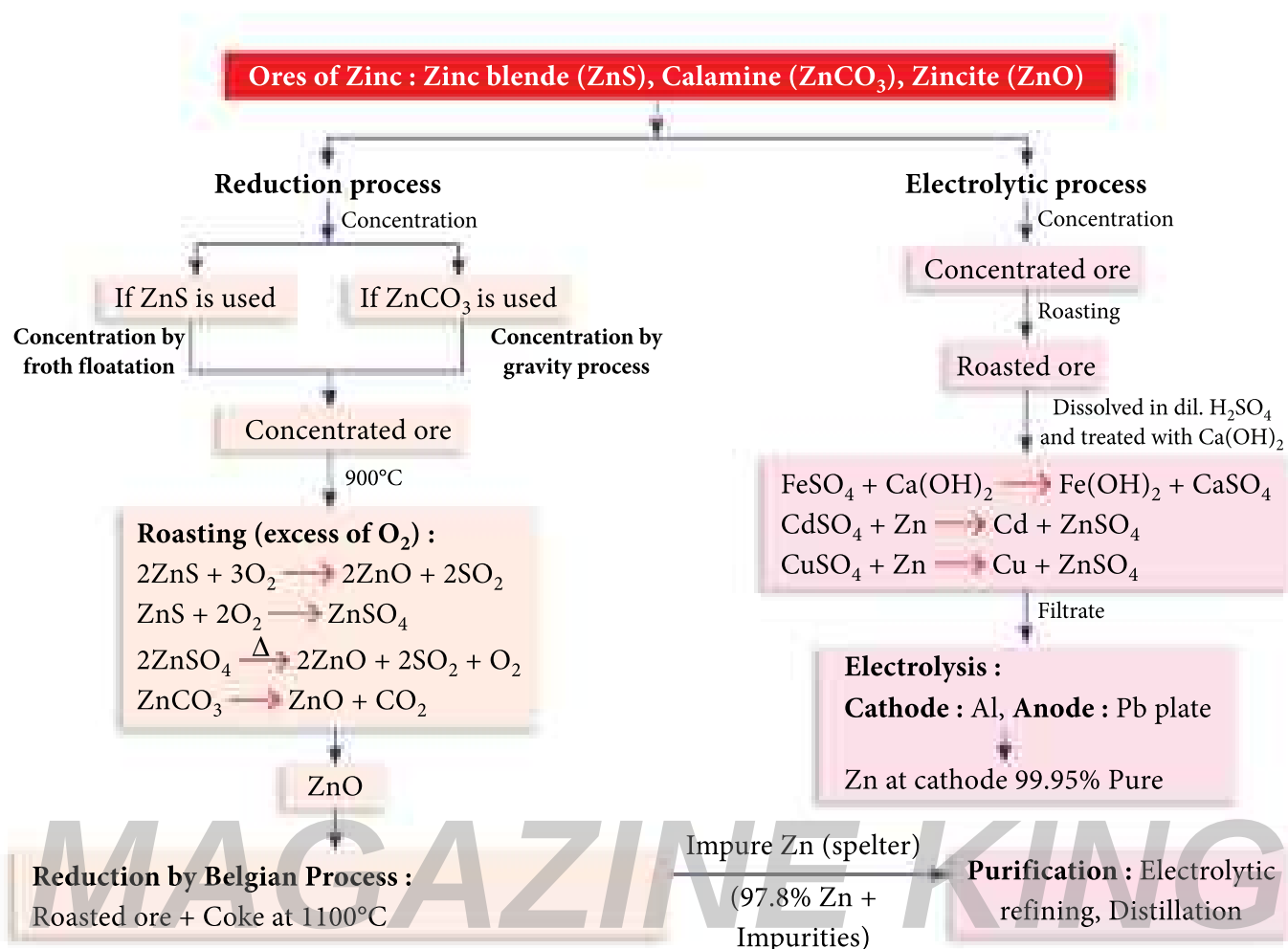
Extraction of Zinc from Zincite

The zinc does not occur in free-state in nature. Its principal ores are zincite (ZnO), zinc blende (ZnS), calamine (ZnCO_3), etc. From the Ellingham diagram, it is evident that intersection of (Zn , ZnO) and (C , CO) curves lies at a higher temperature than that of (Cu , Cu_2O) and (C and CO) curves. Therefore, reduction of ZnO (ore of zinc) with coke is carried out at a higher temperature than that of Cu_2O .



Above 1270 K, $\Delta_f G^\circ$ for ZnO is higher than that of CO_2 and CO from carbon. Therefore, above 1270 K, $\Delta_r G^\circ$ for the reduction of ZnO by carbon is negative and thus ZnO is easily reduced by coke above 1270 K. For the purpose of reduction, ZnO is made into brickettes with coke and clay and heated above 1270 K, usually around 1673 K so that the reduction process essentially goes to completion.

It may, however, be noted here that $\Delta_f G^\circ$ of CO_2 from CO is always higher than that of ZnO . Therefore, CO cannot be used for reduction of ZnO to Zn . Since the boiling point of zinc is low (1180 K), the metal is distilled off and collected by rapid chilling.



Extraction of Aluminium from Alumina

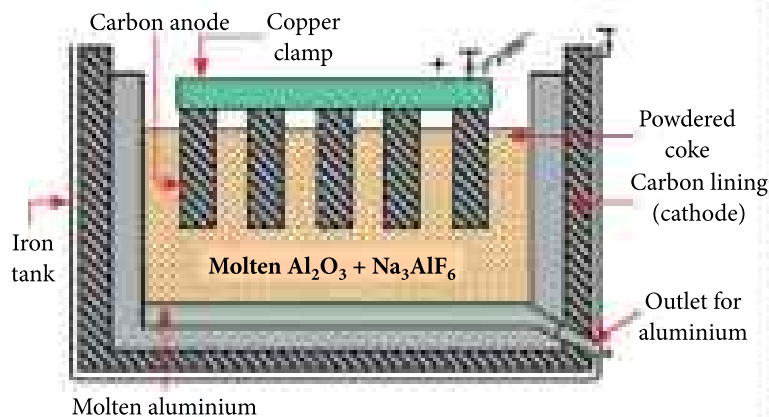
- Fused alumina (Al₂O₃) is a bad conductor of electricity. Hence, cryolite (Na₃AlF₆) and fluorspar (CaF₂) are added to purified alumina, which not only make alumina a good conductor of electricity but also reduce the melting point of the mix to around 1140 K.

- The process of obtaining aluminium by electrolysis of a mixture of purified alumina and cryolite is known as Hall and Heroult process.

- The electrolysis of the molten mass is carried out in an electrolytic cell made of iron using iron electrodes. A layer of powdered coke is used to cover the molten electrolyte to prevent oxidation and temperature of the bath is maintained around 1173 K.

- The reactions that occur during the electrolysis are as follows : **Cathode :** $\text{Al}_{(\text{melt})}^{3+} + 3e^- \rightarrow \text{Al}_{(l)}$
Anode : $\text{C}_{(s)} + \text{O}_{(\text{melt})}^{2-} \rightarrow \text{CO}_{(g)} + 2e^-$; $\text{C}_{(s)} + 2\text{O}_{(\text{melt})}^{2-} \rightarrow \text{CO}_{2(g)} + 4e^-$

- The aluminium metal liberated at the cathode melts at the high temperature (1173 K) of the tank. The molten metal being heavier than the molten electrolyte sinks to the bottom of the tank from where it is withdrawn periodically through the tapping hole. The metal obtained by the process is about 99.95% pure.



Electrolytic cell for extraction of Aluminium

GET SET GO

NEET



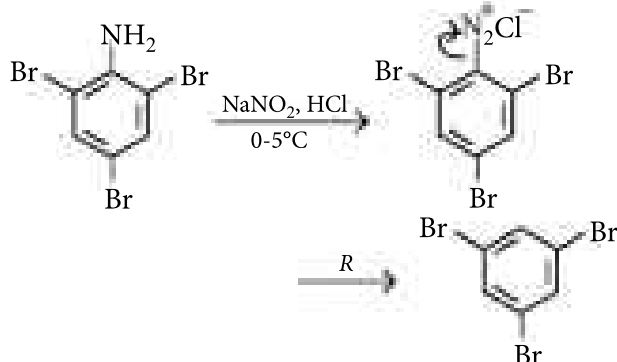
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Practicing these MCQs help to strengthen your concepts and give you extra edge in your NEET preparation

- Specific conductance of 0.1 M nitric acid is $6.3 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$. The molar conductance of the solution is
 (a) $630 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$
 (b) $315 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$
 (c) $6.300 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$
 (d) $63.0 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$
- If the rate of a reaction at 50°C is $2.6 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$, then what will be rate of reaction at 80°C ? (Given that the temperature coefficient is 3.)
 (a) 7.02×10^{-2} (b) 7.025×10^{-3}
 (c) 7.8×10^{-3} (d) None of these
- The volume of a colloidal particle, V_c as compared to volume of solute particle V_s in a true solution could be
 (a) $\frac{V_c}{V_s} \approx 10^{-3}$ (b) $\frac{V_c}{V_s} \approx 10^3$
 (c) $\frac{V_c}{V_s} \approx 1$ (d) $\frac{V_c}{V_s} \approx 10^{23}$
- 0.2 g of acetic acid dimerises when dissolved in 20 g of benzene, decreasing the freezing point by 0.45°C . The degree of association of acetic acid in benzene is $[K_f(\text{benzene}) = 5.12 \text{ K kg mol}^{-1}]$
 (a) 45.9% (b) 94.6% (c) 69.4% (d) 54.9%
- Which of the following statements is incorrect?
 (a) SO_3 is a stronger oxidising agent and more acidic than SO_2 .
 (b) Selenium forms only two oxoacids *i.e.*, selenous acid (H_2SeO_3) and selenic acid (H_2SeO_4).
 (c) The acidic strength and oxidising power of oxo acids is greater in +6 oxidation state than in +4 oxidation state.
 (d) The thermal stability of oxides of group 16 elements decreases in the order $\text{SO}_2 > \text{SeO}_2 > \text{TeO}_2 > \text{PoO}_2$.
- Chlorobenzene $\xrightarrow{\text{Reaction X}}$ Phenol $\xrightarrow{\text{Reaction Y}}$ Salicylaldehyde.
 The name of X and Y reactions are respectively
 (a) Fries rearrangement and Kolbe - Schmidt
 (b) Hoffmann bromamide degradation and Reimer - Tiemann
 (c) Dow and Reimer - Tiemann
 (d) Dow and Friedel - Crafts
- Larger number of oxidation states are exhibited by the actinoids than those by the lanthanoids, the main reason being
 (a) lesser energy difference between $5f$ and $6d$ than between $4f$ and $5d$ orbitals
 (b) more energy difference between $5f$ and $6d$ than between $4f$ and $5d$ orbitals

- (c) more reactive nature of the actinoids than the lanthanoids
(d) $4f$ orbitals are more diffused than the $5f$ orbitals.

8. The reagent in 'R' in the given sequence of chemical reaction is



- (a) CuCN/KCN (b) H_2O
(c) $\text{CH}_3\text{CH}_2\text{OH}$ (d) HI

9. The correct order of intensity of colours of the compounds is

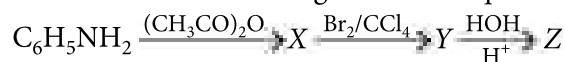
- (a) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+} > [\text{NiCl}_4]^{2-} > [\text{Ni}(\text{CN})_4]^{2-}$
(b) $[\text{NiCl}_4]^{2-} > [\text{Ni}(\text{CN})_4]^{2-} > [\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
(c) $[\text{NiCl}_4]^{2-} > [\text{Ni}(\text{H}_2\text{O})_6]^{2+} > [\text{Ni}(\text{CN})_4]^{2-}$
(d) $[\text{Ni}(\text{CN})_4]^{2-} > [\text{NiCl}_4]^{2-} > [\text{Ni}(\text{H}_2\text{O})_6]^{2+}$

10. A metal crystallises into two cubic phases, face-centred cubic (fcc) and body-centred cubic (bcc) whose edge lengths are $3.5 \text{ \AA}$ and $3.0 \text{ \AA}$ respectively. The ratio of the densities of fcc and bcc is
(a) 2.0 (b) 1.5 (c) 1.75 (d) 1.25

11. Which of the following is not a correct statement?
(a) Cassiterite, chromite and pitchblende are concentrated by hydraulic washing.
(b) Pure Al_2O_3 is obtained from the bauxite ore by leaching in the Baeyer's process.
(c) Sulphide ore is concentrated by calcination method.
(d) Roasting can convert sulphide into oxide or sulphate and part of sulphide may also act as a reducing agent.

12. An alkyl bromide produces a single alkene when it reacts with sodium ethoxide and ethanol. This alkene on hydrogenation produces 2-methylbutane. What is the identity of the alkyl halide?
(a) 1-Bromo-2, 2-dimethylpropane
(b) 1-Bromobutane
(c) 1-Bromo-2-methylbutane
(d) 2-Bromo-2-methylbutane

13. What is Z in the following reactions sequence?



- (a) p -Bromoaniline
(b) Bromoacetophenone
(c) p -Bromoacetanilide
(d) o -Bromoacetophenone

14. An organic compound 'A' has the molecular formula $\text{C}_3\text{H}_6\text{O}$. It undergoes iodoform test. When saturated with HCl , it gives 'B' of molecular formula $\text{C}_9\text{H}_{14}\text{O}$. 'A' and 'B' respectively are

- (a) Propanal and mesitylene
(b) Propanone and mesityl oxide
(c) Propan-2-one and 2, 6-dimethyl-2, 5-heptadien-4-one
(d) Propanone and mesitylene oxide

15. Choose the correct statement from the following.

- (a) Cellulose is a natural polymer having glycosidic linkage.
(b) Protein is a natural polymer having an amide linkage.
(c) Sucrose has a glycosidic linkage.
(d) All of these.

SOLUTIONS

1. (a): $\kappa = 6.3 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$, $C = 0.1 \text{ M}$

$$\Lambda_m = \kappa \times \frac{1000}{C} = 6.3 \times 10^{-2} \times \frac{1000}{0.1} = 630 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$$

2. (a): $n = \frac{80 - 50}{10} = 3$; $\frac{r_{\text{new}}}{r_{\text{old}}} = (3)^n$

$$\text{New rate} = 2.6 \times 10^{-3} \times 3^3 = 70.2 \times 10^{-3} = 7.02 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$$

3. (b): For true solution, the diameter range is 1 to $10 \text{ \AA}$ and for colloidal solution, diameter range is 10 to $1000 \text{ \AA}$.

$$\frac{V_c}{V_s} = \frac{(4/3)\pi r_c^3}{(4/3)\pi r_s^3} = \left(\frac{r_c}{r_s}\right)^3 = \left(\frac{10}{1}\right)^3 = 10^3$$

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

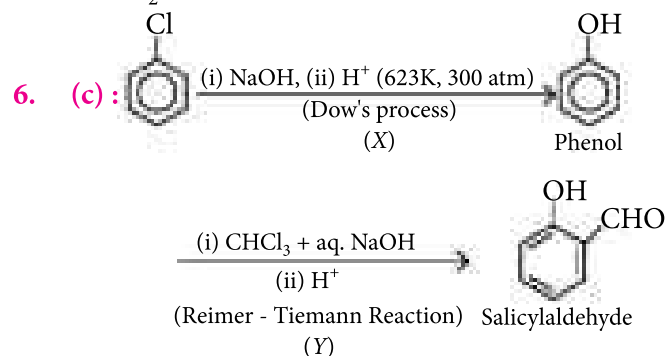
- | | | | | |
|-----------|-------------|-----------|------------|-------------|
| 1. (d) | 2. (b) | 3. (c) | 4. (d) | 5. (b) |
| 6. (b) | 7. (d) | 8. (d) | 9. (b) | 10. (c) |
| 11. (b) | 12. (d) | 13. (c) | 14. (b) | 15. (c) |
| 16. (a) | 17. (b) | 18. (b) | 19. (c) | 20. (a,b,c) |
| 21. (b,c) | 22. (a,b,c) | 23. (c,d) | 24. (7.25) | 25. (3.87) |
| 26. (30) | 27. (c) | 28. (a) | 29. (a) | 30. (b) |

4. (b): $i = \frac{M_B \Delta T W_A}{1000 K_f W_B} = \frac{60 \times 0.45 \times 20}{1000 \times 5.12 \times 0.2} = 0.527$

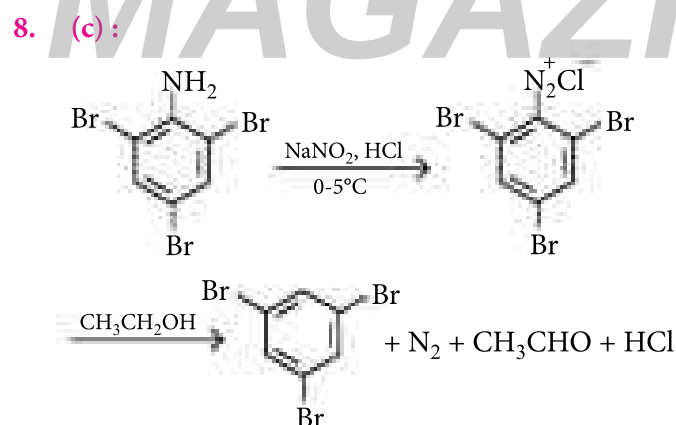
$$\alpha = \frac{1-i}{1-\left(\frac{1}{n}\right)} = \frac{1-0.527}{1-\left(\frac{1}{2}\right)} = 0.473 \times 2 = 0.946$$

$$= 94.6\%$$

5. (d): Thermal stability of the oxides of group 16 elements decreases in the order $\text{SO}_2 > \text{TeO}_2 > \text{SeO}_2 > \text{PoO}_2$ and not in the order as mentioned.



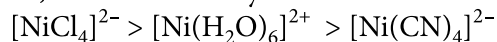
7. (a): Energy difference between $5f$ and $6d$ orbitals is less so, actinoids exhibit larger number of oxidation states.



9. (c): As all complexes have Ni^{2+} , so stronger is the ligand greater is the splitting. Due to greater splitting, the energy gap will be higher so lighter will be the colour.

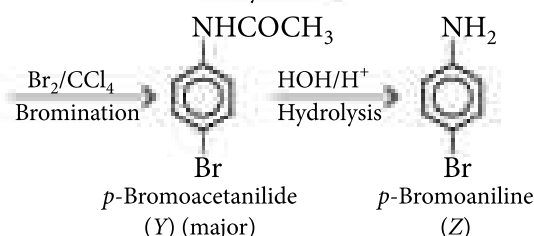
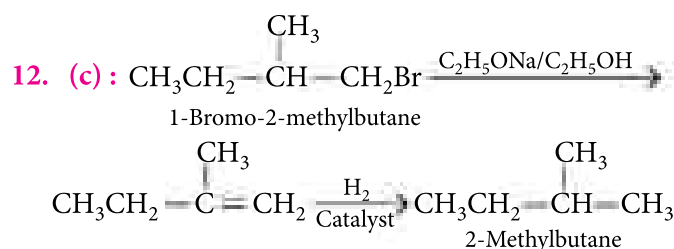
Order of strength of ligand: $\text{Cl}^- < \text{H}_2\text{O} < \text{CN}^-$

So, order of intensity of colour:

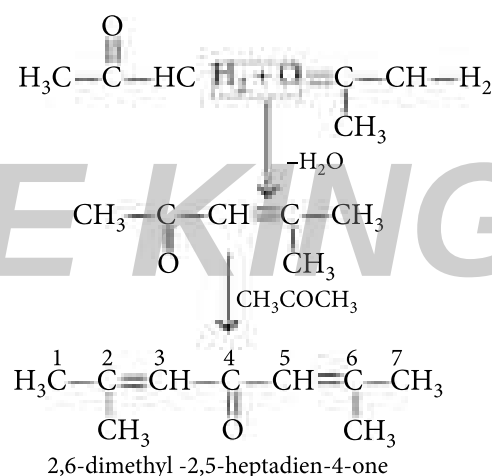


10. (d): $\frac{\rho_{fcc}}{\rho_{bcc}} = \frac{Z_{fcc}}{(a^3)_{fcc}} \times \frac{(a^3)_{bcc}}{Z_{bcc}} = \frac{4 \times (3.0)^3}{2 \times (3.5)^3} = 1.25$

11. (c): Sulphide ores are concentrated by froth floatation method. Galena (PbS), zinc blende (ZnS) and copper pyrites (CuFeS_2) are concentrated by this method.



14. (c): 3 Molecules of propan-2-one undergoes condensation.



15. (d): All the given statements are correct.

SOLUTIONS TO AUGUST 2023 QUIZ CLUB

- | | |
|---------------|---|
| 1. Isotope | 11. Square pyramidal |
| 2. Platinum | 12. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ |
| 3. Vitamin A | 13. Incineration |
| 4. Aniline | 14. Antarctica |
| 5. Lattice | 15. Negative |
| 6. Viscosity | 16. 1 |
| 7. 7.5 | 17. Calcium phosphate |
| 8. Amphoteric | 18. Poling |
| 9. Temporary | 19. Schiff's |
| 10. Lithium | 20. Dextran |

Winner : Kaushikkumar Kevadiya

BRUSH UP ^{for} NEET/JEE

CLASS-XII

Brush up your concepts to get high rank in NEET/JEE (Main and Advanced) by reading this column. This specially designed column is updated year after year by a panel of highly qualified teaching experts well-tuned to the requirements of these Entrance Tests.

Unit 4

Haloalkanes and Haloarenes | Alcohols, Phenols and Ethers

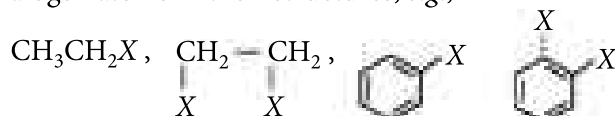
HALOALKANES AND HALOARENES

Compounds formed as a result of replacement of one or more hydrogen atoms by equal number of halogen atoms within aliphatic or aromatic hydrocarbons are considered as halogen derivatives.

CLASSIFICATION OF HALOALKANES AND HALOARENES

On the basis of number of halogen atoms

Haloalkanes and haloarenes can be classified as mono, di or polyhalogen (tri-, tetra-, etc.) compounds depending on whether they contain one, two or more halogen atoms in their structures, e.g.,

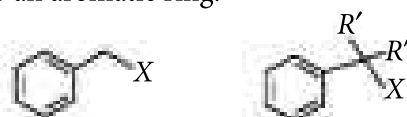


Monohaloalkane Dihaloalkane Monohaloarene Dihaloarene

On the basis of nature of C—X bond

- Compounds containing sp^3 hybridised C—X bond :
 - Alkyl halides or haloalkanes ($R-X$)** : The halogen atom is attached to an alkyl group with general homologous formula $C_nH_{2n+1}X$. They are further classified into mainly three types on the basis of the carbon atom to which the carbon bearing halogen (X) atom is bonded, i.e., primary, secondary and tertiary.
 - Allylic halides** : When a halogen atom is attached to a sp^3 hybridised carbon atom present next to a carbon - carbon double bond ($C=C$).
 - Benzylic halides** : This type of compound is formed when halogen is attached to an sp^3

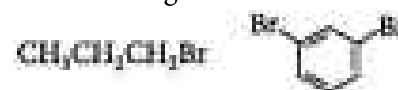
hybridised carbon atom which is present next to an aromatic ring.



- Compounds containing sp^2 hybridised C—X bond :
 - Vinyllic halides** : These compounds are formed when halogen atom is attached to a sp^2 hybridised carbon atom of a carbon - carbon double bond ($C=C$).
 - Aryl halides** : This class of compounds is formed when the halogen atom is bonded to an sp^2 -hybridised carbon atom an aromatic ring.

NOMENCLATURE OF HALOALKANES AND HALOARENES

In the common system, alkyl group is named first followed by the halide. In the International Union of Pure and Applied Chemistry (IUPAC) system of nomenclature, alkyl halides are named as haloalkanes. Aryl halides are named by prefixing 'halo' to the name of the parent aromatic hydrocarbon. If there are more than one substituents on the ring, then the relative positions of the substituents are indicated by mathematical numerals. In common system the relative position of two groups is shown by prefixes *ortho* (*o*-), *meta* (*m*-) or *para* (*p*-). The common and IUPAC names of some representative haloarenes are given as:



Common name : *n*-Propyl bromide *m*-Dibromobenzene

IUPAC name : 1-Bromopropane 1, 3-Dibromobenzene

NATURE OF C—X BOND

In haloalkanes, the halogen atom is bonded to an alkyl group. The carbon atom is sp^3 hybridised. The C—X bond is highly polarised covalent bond due to large difference in the electronegativities of carbon and halogen atoms.



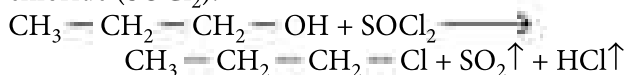
METHODS OF PREPARATION OF HALOALKANES

- **From alcohols :** In laboratory, haloalkanes are very conveniently obtained from alcohols. The process involves the substitution of —OH group of alcohols by halogen atom.

Iodoalkane is obtained by heating alcohol with HI.



- **By reaction with thionyl chloride :** Chloroalkanes can be obtained by treatment of alcohol with thionyl chloride (SOCl_2).



- **By treatment with phosphorus halides :** Alcohols react with phosphorus halides (PX_5 or PX_3) to form alkyl halides.

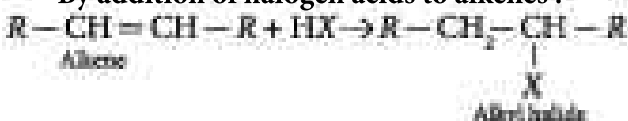


- **From hydrocarbons**

- **By free radical halogenation of alkanes :**



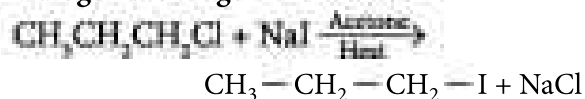
- **By addition of halogen acids to alkenes :**



- **By addition of halogens to alkenes :** The addition of bromine results in the synthesis of *vic*-dibromides, which are colourless.



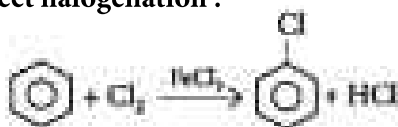
- **Halogen exchange**



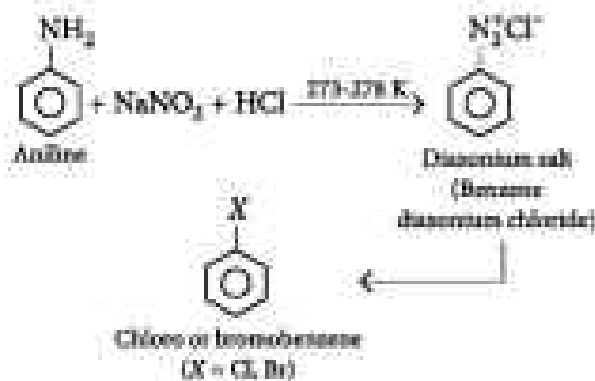
This reaction is known as Finkelstein reaction.

METHODS OF PREPARATION OF HALOALKANES

- **By direct halogenation :**

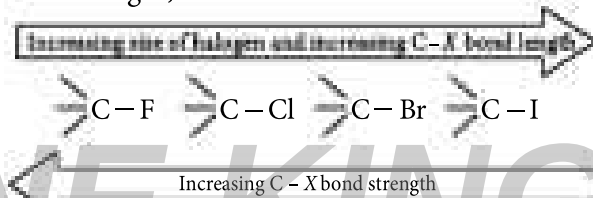


- **By decomposition of diazonium salts (Sandmeyer's reaction) :**



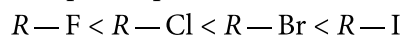
PHYSICAL PROPERTIES OF HALOALKANES

- **Bond strength :** In haloalkanes bond strength of carbon-halogen bond decreases with an increase in bond length, as one moves from fluorine to iodine.



- **Solubility and state of matter :** Haloalkanes are insoluble in water but soluble in organic solvents. Lower molecular mass haloalkanes are gases at room temperature while higher haloalkanes upto C_{18} are liquid at room temperature. Alkyl halides beyond C_{18} are colourless solids.

- **Boiling point :** Boiling points of haloalkanes are higher as compared to corresponding alkanes due to dipole-dipole interaction.

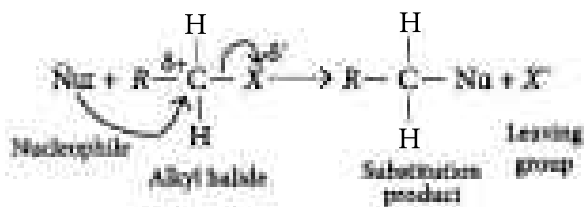


CHEMICAL PROPERTIES OF HALOALKANES

Alkyl halides are very reactive compounds. They undergo substitution, elimination and reduction reactions. Alkyl halides also react with metals to form organometallic compounds.

Nucleophilic Substitution Reactions

The carbon-halogen bond in alkyl halides is polar because of the high electronegativity of the halogen atom relative to carbon. The carbon atom is therefore a good target for attack by nucleophiles (electron rich species). In fact, the nucleophilic substitution reactions are the most common reactions of alkyl halides. They may be represented as,



- Formation of cyanides or nitriles :**
 Haloalkanes on treatment with alcoholic KCN solution give alkane nitriles or alkyl cyanides as the major product with a small amount of alkyl isocyanide.



- Formation of isocyanides :**



Mechanism of Nucleophilic Substitution Reaction

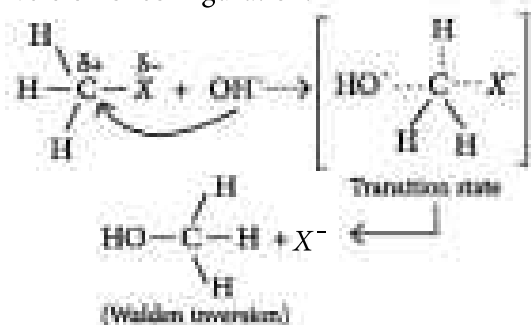
Nucleophilic substitution reactions can proceed via two different mechanisms $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$.

- $\text{S}_{\text{N}}1$ (Unimolecular nucleophilic substitution) :**
 This reaction occurs in two steps. In step (I), a carbocation and a halide ion is formed. First step is a slow step and therefore it is the rate determining step. In step (II), a nucleophile attacks on the carbocation and forms the final product. Since the rate of a reaction depends on the slowest step thus, here the rate of reaction depends only on the concentration of the alkyl halide and not on the concentration of OH^- ion.

i.e., Rate of reaction $\propto [(\text{CH}_3)_3\text{C}-\text{X}]$. It is a unimolecular substitution reaction.

- $\text{S}_{\text{N}}2$ (Bimolecular nucleophilic substitution) :** The rate of $\text{S}_{\text{N}}2$ reactions depends on the concentration of alkyl halide as well as the nucleophile, *i.e.*, $r = k [\text{RX}][\text{Nu}^-]$. This implies that both the reactants are involved in the rate-determining step, *i.e.*, the reaction occurs in one step only or it is a concerted reaction.

The product obtained will have an invert configuration (Walden inversion). This is known as inversion of configuration.



This implies that if the alkyl halide is optically active, the product will also be optically active, although the sign of rotation may be same or different.

Since this reaction involves the attack of the nucleophile from the back side of the halide ion, presence of a bulky alkyl group on or near the carbon bearing halogen, hinders the approach of the nucleophile.

The reactivity of alkyl halides towards $\text{S}_{\text{N}}2$ mechanism is $1^\circ > 2^\circ > 3^\circ$ approach of the nucleophile.

Stereochemical Aspects of Nucleophilic Substitution Reactions

Stereochemistry of $\text{S}_{\text{N}}2$ reaction : In $\text{S}_{\text{N}}2$ reaction, the nucleophile attacks from the back side so the product acquires the inverted configuration. When (–)-2-bromooctane is treated with aqueous NaOH, (+)-octan-2-ol is formed in which –OH group occupies the position opposite to what was occupied by –Br in the reactant molecule. This type of inversion of configuration is also known as Walden inversion.



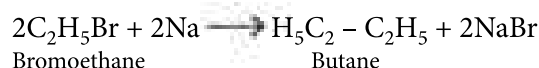
Elimination Reactions

- The positive charge on the carbon gets propagated to the neighbouring carbon atoms due to inductive effect.
- When a strong base approaches the carbocation, it tends to lose a proton from the β -carbon atom, the reactions are called α, β - elimination reactions.
- Action of heat :** On heating the alkyl halide above 300°C , the corresponding alkene is formed.

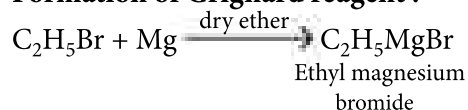


Reaction with Metal

- Wurtz reaction :**



- Formation of Grignard reagent :**



PHYSICAL PROPERTIES OF HALOARENES

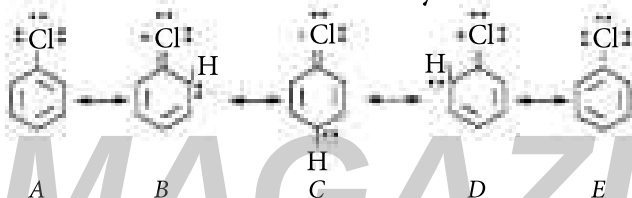
- Aryl halides are colourless stable liquids with pleasant odour.
- These are insoluble in water but readily miscible with organic solvents.
- Most of them are steam volatile, heavier than water.
- Their boiling points are higher than corresponding alkyl halides. The boiling points rise gradually from fluoro to iodo compounds.

CHEMICAL PROPERTIES OF HALOARENES

Nucleophilic Aromatic Substitution Reactions

- As compared to alkyl halides, aryl halides are very less reactive towards nucleophilic substitution.
- The low reactivity of haloarenes can be explained on the basis of :

– Delocalisation of electrons by resonance

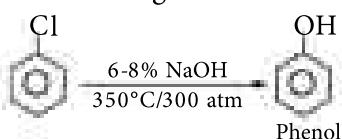


The haloarenes are stabilised by resonance, structures B, C and D show a double bond between carbon and chlorine (halogen) atom which strengthens the bond and makes it more stable towards nucleophilic substitution.

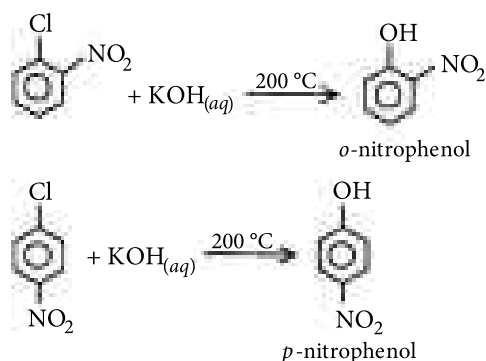
– Difference in hybridisation of carbon atom in C–X bond :

In alkyl halides, the carbon atom attached to halogen atom is sp^3 hybridised whereas in aryl halides, it is sp^2 hybridised. The sp^2 hybridised carbon is more electronegative hence, the bond with halogen is shorter and stronger resulting in lower reactivity.

- Aryl halides undergo nucleophilic substitution reactions under drastic conditions or when a strong electron withdrawing group is attached to the benzene ring.



- Presence of an electron withdrawing group (e.g., $-\text{NO}_2$, $-\text{CN}$, $-\text{SO}_3\text{H}$ etc.) activates the benzene ring by dispersing the negative charge on the carbanion, thus stabilising it and facilitating nucleophilic substitution, e.g.



- Presence of electron releasing groups (e.g., $-\text{OH}$, $-\text{NH}_2$, $-\text{R}$ etc.) deactivates the ring by intensifying the charge on the carbanion, thus destabilising it and slowing the rate of nucleophilic substitution.

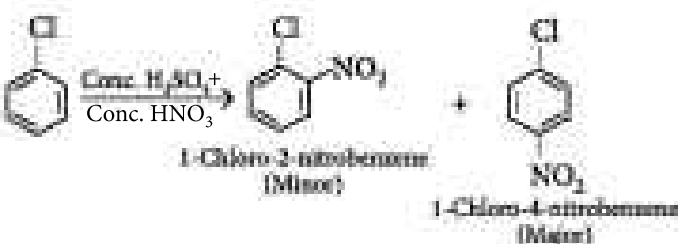
Electrophilic Substitution Reactions

The halogen atom in aryl halides is highly electronegative relative to carbon and hence $\text{C}-\text{Cl}$ bond is polarised. This makes the carbon atom positive and it withdraws electrons from the benzene ring (Inductive effect or $-I$ effect) thus deactivating it.

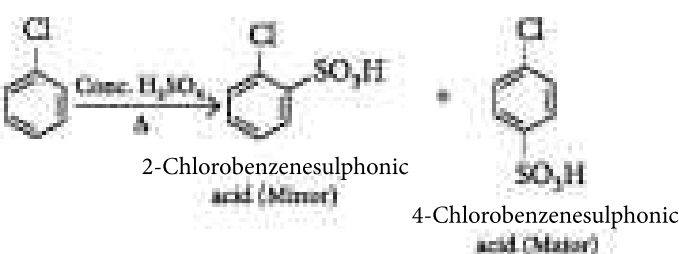
- **Halogenation :**



- **Nitration :**



- **Sulphonation :**

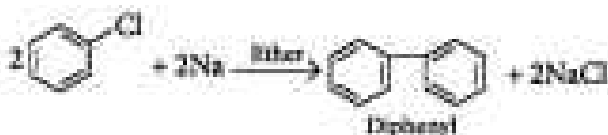


- **Reaction with metals**

- **Wurtz–Fittig reaction :** Aryl halides coupled with alkyl halides when heated with sodium in dry ether solution, to form alkylbenzene.



- **Fittig reaction** : Aryl halides also give analogous compounds when treated with sodium in dry ether, in which two aryl groups are joined together. It is called Fittig reaction.



ALCOHOLS, PHENOLS AND ETHERS

- Alcohols are regarded as hydroxy derivatives of hydrocarbons. These are formed by the replacement of one, two or more hydrogen atoms of a hydrocarbon by a corresponding number of hydroxyl groups (–OH).



- The compounds in which hydroxyl group is attached to a saturated carbon atom are called as alcohols. The compounds in which a hydroxyl group is attached to an unsaturated carbon atom of a double bond are called as enols. The saturated carbon may be that of an alkyl, alkenyl or benzyl group. However, if a hydroxyl group is attached to a benzene ring, the compound is called as phenol.

Nomenclature of Alcohols

- Common name** : The common name of an alcohol is derived from common name of alkyl group and adding the word alcohol to it. For example, $\text{C}_2\text{H}_5\text{OH}$ is ethyl alcohol.
- IUPAC name** : The steps involved in nomenclature of monohydric alcohol are as follows :
Step 1 : Name the longest chain to which the hydroxyl (–OH) group is attached. The name for this chain is obtained by dropping the final –e from the name of the hydrocarbon parent name with suffix –ol.
Step 2 : Number the longest chain to give the lowest possible number to the carbon bearing the hydroxyl group.
Step 3 : Locate the position of the hydroxyl (–OH) group by the number of the carbon to which it is attached.
Step 4 : Locate and name any other substituents.
Step 5 : Combine the name and location for other groups, the hydroxyl group location, and the longest chain into the final name.

Nomenclature of Phenols

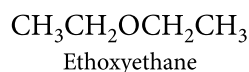
- The simplest hydroxyl derivative of benzene is phenol. Phenol is the common name as well as an accepted IUPAC name of the compound.
- In the case of substituted phenol compounds, the terms *ortho* (1,2-disubstituted), *meta* (1,3-disubstituted) and *para* (1,4-disubstituted) are often used as prefixes in the common names. However, in the IUPAC system, Arabic numerals are used to indicate the position of the substituent w.r.t. –OH group.

Nomenclature of Ethers

- Common system** : The common names of ethers are derived by naming the two alkyl or aryl groups linked to the oxygen atom as separate words in alphabetical order and adding the word ether. In case of symmetrical ethers, we use the prefix ‘di’ before the name of the alkyl or the aryl group.



- IUPAC system** : In the IUPAC system, ethers are named as alkoxyalkanes. The ethereal oxygen is taken with the smaller alkyl group and forms a part of the alkoxy group. On the other hand, the larger alkyl group is taken to be the part of the alkane.



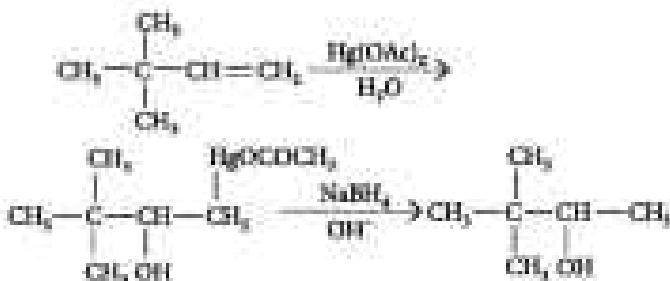
Structure of Alcohols, Phenols and Ethers

- The oxygen atom and the carbon atom form sigma bond by the overlap of sp^3 hybridised orbital. Alcohols have tetrahedral geometry with two sp^3 hybridised orbitals of oxygen atom having two lone pair of electrons.
- In phenols, the –OH group is attached to sp^2 hybridised carbon of an aromatic ring. The C–O–H bond angle in phenols is slightly less than the tetrahedral angle ($109^\circ 28'$) due to the repulsion between two lone pairs of electrons present on oxygen.
- In ethers the central oxygen atom is sp^3 hybridised with two completely filled sp^3 hybridised orbitals having lone pair of electrons and two half filled sp^3 hybridised orbitals.

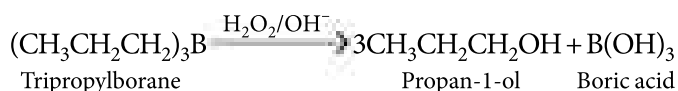
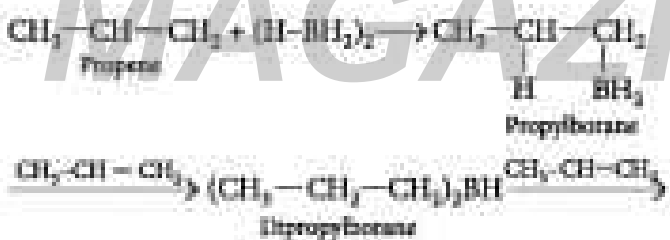
PREPARATION OF ALCOHOLS, PHENOLS AND ETHERS

Preparation of Alcohols

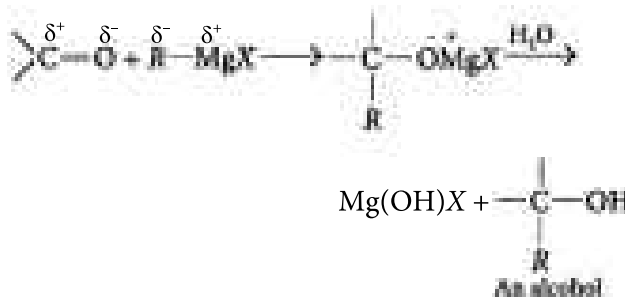
- By **oxymercuration-demercuration** : The addition of water molecule to unsymmetrical alkene according to Markovnikov's rule.



- By **hydroboration-oxidation** : Diborane (BH_3)₂ reacts with alkenes to give trialkyl boranes as addition product which further oxidises to alcohols by hydrogen peroxide in the presence of aqueous sodium hydroxide.



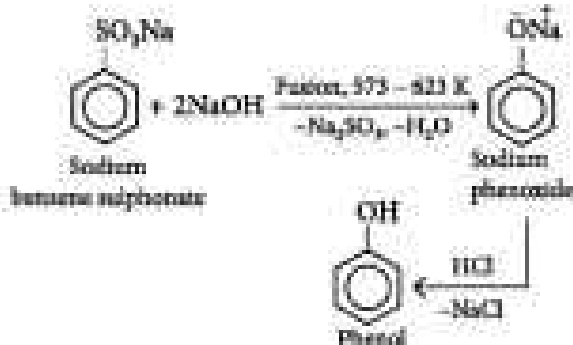
- From Grignard reagent** : The carbon-magnesium bond of the Grignard reagent is a highly polar bond, with carbon being negatively charged relative to electropositive magnesium. When Grignard reagent is added to carbonyl compounds, the organic group attaches to carbon and the magnesium attaches to oxygen.



The product of the first step is a magnesium salt of weakly acidic alcohol and is easily converted into the alcohol by the addition of water.

Preparation of Phenols

- Alkali fusion of sodium benzene sulphonate**



- From diazonium salts**



- From chlorobenzene (Dow's process)**



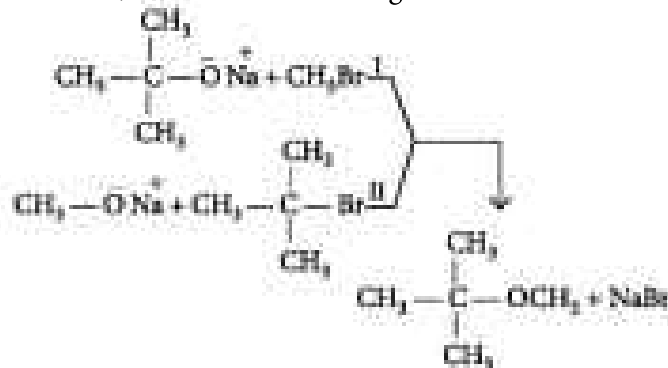
Preparation of Ethers

- Williamson's ether synthesis** : This method involves the treatment of sodium alkoxide with alkyl halide (preferably 1°).

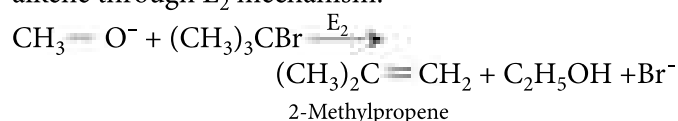


This method usually proceeds by S_N2 mechanism, hence the polar aprotic solvent and low temperature always favours good yield of product. When applied to unsymmetrical ethers, two different combinations of reactants are possible. Since alkoxide anions are strong bases, the possibility of a competing E₂ elimination must always be considered. Bearing in mind the factors that favours substitution over elimination reaction, 1° alkyl halide should be selected as a preferred reactant whenever possible.

Now, consider the following reactions :



Out of path I and II, path II is not at all advisable since it preferably yields alkene. This is due to the fact that the strong base (CH_3O^-) reacts with 3° alkyl halide to give alkene through E_2 mechanism.



PHYSICAL PROPERTIES OF ALCOHOLS, PHENOLS AND ETHERS

Physical Properties of Alcohols

- **Physical state** : Lower members are colourless liquids having a characteristic smell and burning taste, whereas the higher members are colourless, odourless, wax-like solids.
- **Boiling point** : Lower members of alcohols have low boiling points. With increase in molecular mass, boiling point increases because of increase in van der Waals' forces.

Physical Properties of Phenols

- **Physical state** : Phenols are colourless liquids or low melting solids. But they turn reddish brown due to auto oxidation on exposure to air and light.
- **Boiling point** : Boiling points of phenols are higher in comparison to other hydrocarbons with equal molecular masses. This is due to the presence of intermolecular hydrogen bonding between hydroxyl groups of phenol molecules.

Physical Properties of Ethers

- **Physical state** : Dimethyl ether and ethylmethyl ether are exceptionally gases at room temperature whereas all other ethers are colourless liquids with characteristic ethereal smell.
- **Boiling point** : Ethers have much lower boiling points than isomeric alcohols. This is due to the presence of hydrogen bonding in alcohols.

CHEMICAL PROPERTIES OF ALCOHOLS

Reactions Involving Cleavage of O—H Bond

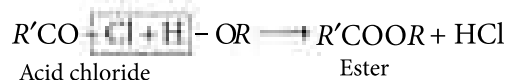


- **Ester formation** : Alcohols react with acids to give esters in presence of conc. H_2SO_4 . The reaction is known as esterification.



The order of ease of formation of ester : Methanol > Primary alcohol > Secondary alcohol > Tertiary alcohol

- **Reaction with acid chlorides** :

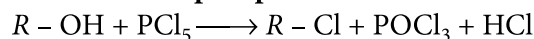


- **Reaction with Grignard reagent** :

Alcohols react with Grignard reagent to form alkane corresponding to alkyl group of Grignard reagent.

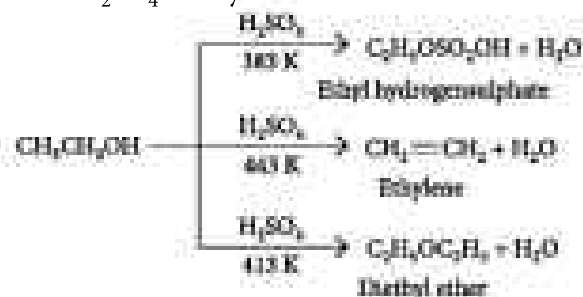


- **Reaction with phosphorus halides** :



Reactions Involving Alcohol Molecule as a Whole

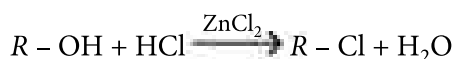
- **Dehydration of alcohols** : The reaction of alcohol with H_2SO_4 is very sensitive to reaction conditions :



- **Action of copper** : When vapours of 1° , 2° and 3° alcohols are passed over hot reduced copper at 300°C , they give different products.

Methods of Distinction between Primary, Secondary and Tertiary Alcohols

- **Lucas test** : Alcohols react with concentrated hydrochloric acid in presence of anhydrous zinc chloride to form alkyl halides.



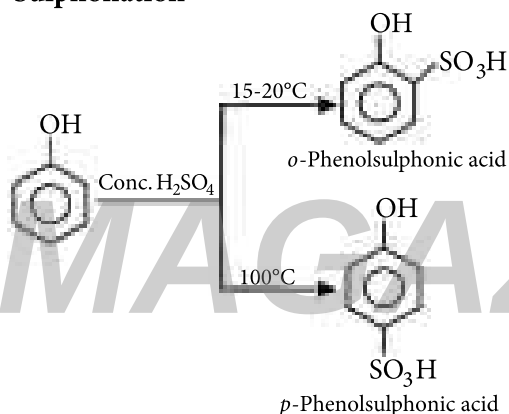
- If cloudiness appears immediately, the alcohol is tertiary.
- If cloudiness appears within 5-10 minutes, the alcohol is secondary.
- If the solution remains clear, *i.e.*, no cloudiness is formed, the alcohol is primary.

CHEMICAL PROPERTIES OF PHENOLS

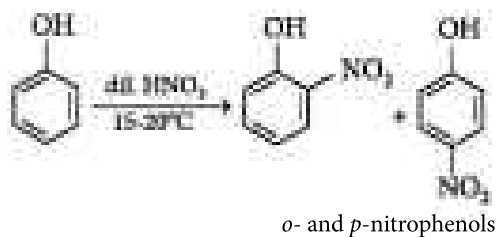
Electrophilic Substitution Reactions of Phenols

The hydroxyl group in phenol is *o*- and *p*- directing and it activates the benzene nucleus towards electrophilic substitutions.

• Sulphonation



• Nitration



• Reimer-Tiemann Reaction

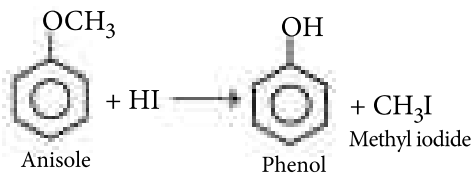
Phenol reacts with chloroform and aqueous alkali followed by hydrolysis to yield a hydroxy benzaldehyde.



CHEMICAL PROPERTIES OF ETHERS

- **Cleavage of alkyl aryl ethers :** Alkyl aryl ethers always give phenol and alkyl halide on cleavage

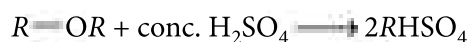
with HI. This can be explained by preferred attack of halide ion on less sterically hindered alkyl group rather than aryl group.



• Action of $\text{dil. H}_2\text{SO}_4$:



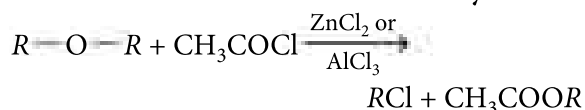
• Action of $\text{conc. H}_2\text{SO}_4$:



• Action of PCl_5 :



• Action of acid chloride and acid anhydride :



• Halogenation :



WebG

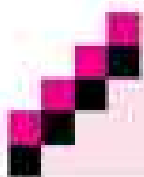
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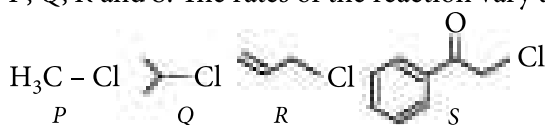
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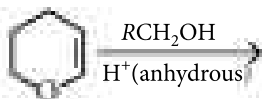
WRAP it up!

MCQs TYPE QUESTIONS

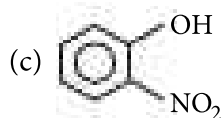
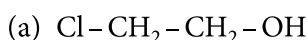
1. KI in acetone undergoes S_N2 reaction with each of P, Q, R and S. The rates of the reaction vary as



- (a) $P > Q > R > S$ (b) $S > P > R > Q$
 (c) $P > R > Q > S$ (d) $R > P > S > Q$
2. The major product of the following reaction is



- (a) a hemiacetal (b) an acetal
 (c) an ether (d) an ester.
3. $\text{CH}_3\text{CH}_2\text{Cl} \xrightarrow{\text{NaCN}} \text{X} \xrightarrow{\text{Ni}/\text{H}_2} \text{Y} \xrightarrow{\text{Acetic anhydride}} \text{Z}$
 Z in the above reaction sequence is
- (a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{NHCOCH}_3$
 (b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$
 (c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONHCH}_3$
 (d) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONHCOCH}_3$.
4. Which one of the following compounds is most acidic?

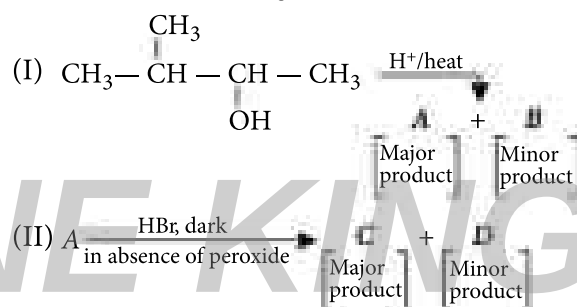


5. Which of the following resonating structures of 1-methoxybuta-1,3-diene is least stable?
- (a) $\text{CH}_2=\text{CH}=\text{CH}-\text{CH}=\text{O}^+-\text{CH}_3$
 (b) $\text{CH}_2=\text{CH}=\text{CH}-\text{CH}=\text{O}-\text{CH}_3$
 (c) $\text{CH}_2=\text{CH}-\text{CH}=\text{CH}=\text{O}^+-\text{CH}_3$
 (d) $\text{CH}_2=\text{CH}-\text{CH}=\text{CH}-\text{O}^+-\text{CH}_3$
6. Given below are two statements :
- Statement I :** On heating with KHSO_4 , glycerol is dehydrated and acrolein is formed.

Statement II : Acrolein has fruity odour and can be used to test glycerol's presence.

In the light of the above statements, choose the correct option.

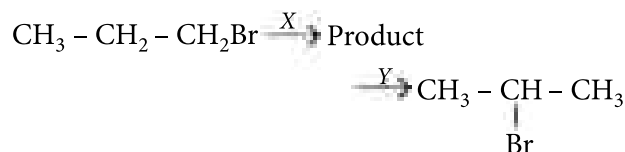
- (a) Both statement I and statement II are correct.
 (b) Both statement I and statement II are incorrect.
 (c) Statement I is correct but statement II is incorrect.
 (d) Statement I is incorrect but statement II is correct.
7. Consider the following reactions,



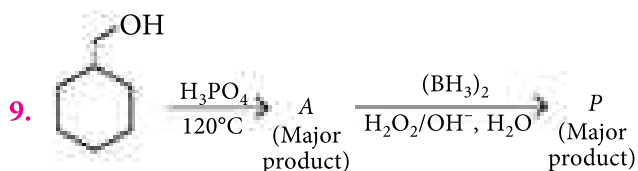
The major products (A) and (C) are respectively

- (a) $\text{H}_2\text{C}=\text{C}(\text{CH}_3)-\text{CH}_2-\text{CH}_3$ and $\text{CH}_2(\text{Br})-\text{CH}(\text{CH}_3)-\text{CH}_2-\text{CH}_3$
 (b) $\text{H}_3\text{C}-\text{C}(\text{CH}_3)=\text{CH}-\text{CH}_3$ and $\text{H}_3\text{C}-\text{C}(\text{CH}_3)(\text{Br})-\text{CH}_2-\text{CH}_3$
 (c) $\text{H}_2\text{C}=\text{C}(\text{CH}_3)-\text{CH}_2-\text{CH}_3$ and $\text{H}_3\text{C}-\text{CH}(\text{CH}_3)-\text{CH}(\text{Br})-\text{CH}_3$
 (d) $\text{H}_3\text{C}-\text{C}(\text{CH}_3)=\text{CH}-\text{CH}_3$ and $\text{H}_3\text{C}-\text{CH}(\text{CH}_3)-\text{CH}(\text{Br})-\text{CH}_3$

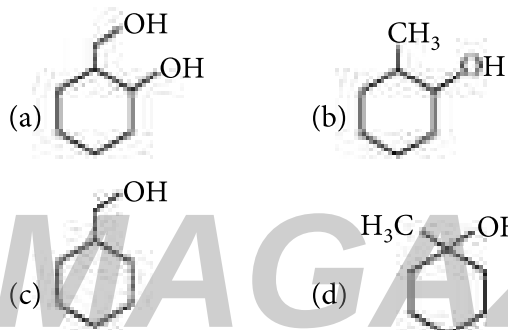
8. Identify the set of reagent/reaction conditions X and Y in the following set of transformations.



- (a) $X = \text{dilute aqueous NaOH, } 20^\circ\text{C};$
 $Y = \text{HBr/acetic acid, } 20^\circ\text{C}$
 (b) $X = \text{concentrated alcoholic NaOH, } 80^\circ\text{C};$
 $Y = \text{HBr/acetic acid, } 20^\circ\text{C}$
 (c) $X = \text{dilute aqueous NaOH, } 20^\circ\text{C};$
 $Y = \text{Br}_2/\text{CHCl}_3, 0^\circ\text{C}$
 (d) $X = \text{concentrated alcoholic NaOH, } 80^\circ\text{C};$
 $Y = \text{Br}_2/\text{CHCl}_3, 0^\circ\text{C}$



Identify the product P.



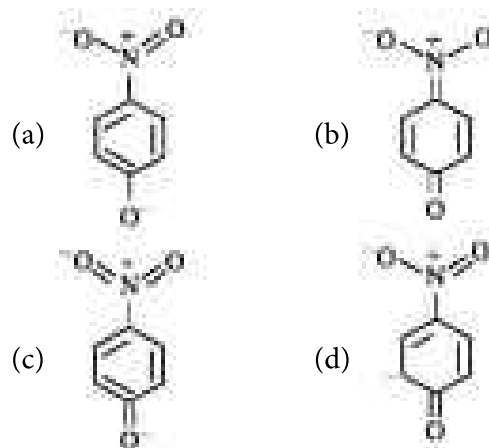
10. Match the column I with column II and mark the appropriate choice.

Column I		Column II	
(A)	Williamson's synthesis	(i)	$\text{C}_6\text{H}_5\text{OH} + \text{CH}_3\text{COCl}$ in presence of pyridine
(B)	ROR'	(ii)	$\text{C}_2\text{H}_5\text{ONa} + \text{C}_2\text{H}_5\text{Br}$
(C)	p -Nitrophenol	(iii)	Unsymmetrical ether
(D)	Acetylation	(iv)	Intermolecular hydrogen bonding

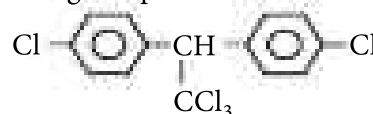
- (a) (A) $\rightarrow$ (i), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iv)
 (b) (A) $\rightarrow$ (iii), (B) $\rightarrow$ (i), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iv)
 (c) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (i)
 (d) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (i), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (iii)

11. When phenol is treated with PCl_5 , the yield of chlorobenzene is generally poor because of the formation of
 (a) benzoyl chloride (b) p -chlorophenol
 (c) o -chlorophenol (d) triphenyl phosphate.

12. The most unlikely representation of resonance structures of p -nitrophenoxide ion is

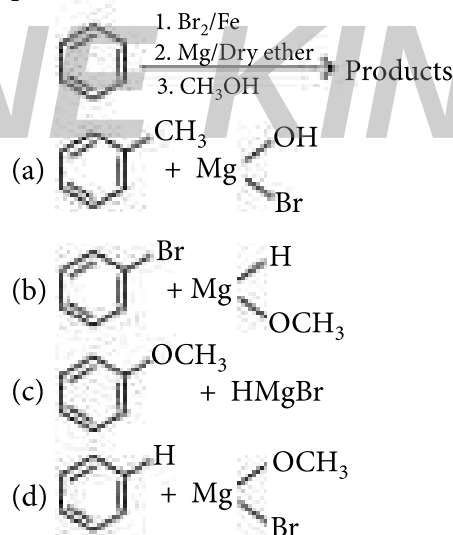


13. The following compound is called



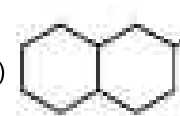
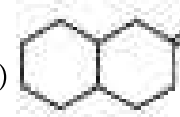
- (a) Chloral (b) DDT
 (c) Lindane (d) BHC.

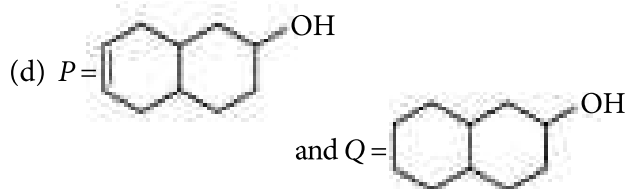
14. For the following sequence of reactions, the correct products are



15. What are P and Q in the following reactions?



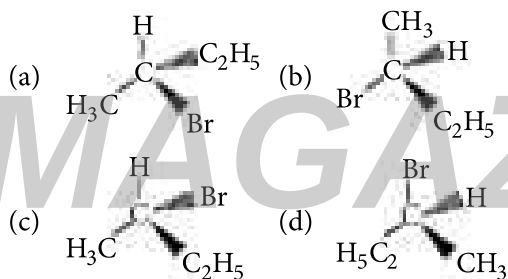
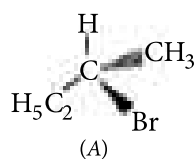
- (a)  in both the cases
 (b)  in both the cases
 (c)  in both the cases



16. Increasing order of reactivity of the following alkyl halides in the Williamson's synthesis is

- I. $CH_2=CHCH_2Cl$ II. $CH_3CH_2CH_2Br$
 III. $(CH_3)_3CCH_2Br$ IV. $CH_3CH_2CH_2Cl$
 (a) $II < III < IV < I$ (b) $III < II < IV < I$
 (c) $IV < III < I < II$ (d) $III < IV < II < I$

17. Which of the following structures is enantiomeric with the molecule (A) given below?



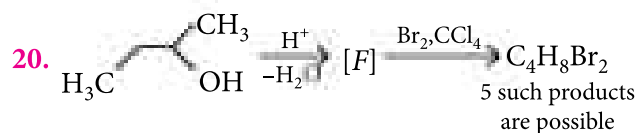
18. *Ortho*-nitrophenol is less soluble in water than *p*- and *m*-nitrophenols because

- (a) *o*-nitrophenol shows intramolecular H-bonding
 (b) *o*-nitrophenol shows intermolecular H-bonding
 (c) melting point of *o*-nitrophenol is lower than those of *m*- and *p*-isomers
 (d) *o*-nitrophenol is more volatile than those of *m*- and *p*-isomers.

19. Match the isomers given in column I with their names given in column II and mark the appropriate choice.

Column I		Column II	
(A)		(i)	2-Bromo-3-methylbutane
(B)		(ii)	2-Bromopentane
(C)		(iii)	1-Bromo-3-methylbutane
(D)		(iv)	1-Bromo-2-methylbutane

- (a) (A) $\rightarrow$ (iii), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (ii)
 (b) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (i)
 (c) (A) $\rightarrow$ (i), (B) $\rightarrow$ (ii), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (iv)
 (d) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (iv), (D) $\rightarrow$ (i)

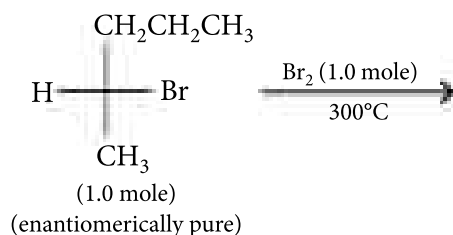


How many structures of F are possible?

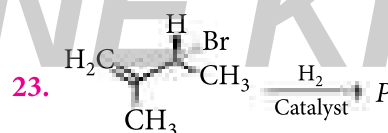
- (a) 2 (b) 5 (c) 6 (d) 3

NUMERICAL VALUE TYPE QUESTIONS

21. In the following monobromination reaction, the number of possible chiral products is _____.



22. Pyrogallol is x, y, z -trihydroxy benzene. What is the value of $x + y + z$?



The number of chiral centres present in product P is _____.

24. How many of the following groups, if substituted at *ortho* and *para* position of chlorobenzene increase its reactivity towards nucleophilic substitution?

$-CN$, $-CH_3$, $-COOH$, $-NO_2$, $-OCH_3$

25. Phenol on oxidation gives *p*-benzoquinone which has _____ number of hydrogen atoms.



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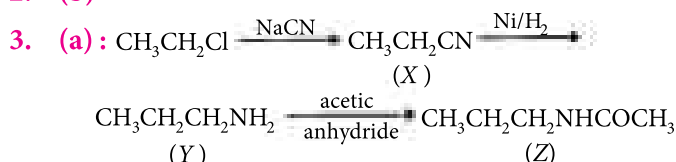
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SOLUTIONS

1. (b) : The bulky groups cause steric hindrance in the formation of transition state. Therefore, higher homologue (Q) and (R) are less reactive than lower homologue (P). (R) is more reactive than (Q) as in (Q) two $-\text{CH}_3$ groups are directly attached to C – Cl bond. In compound (S), the transition state is highly stabilized by $\left(\text{Ph} - \overset{\text{O}}{\parallel}{\text{C}} - \right)$ group, so it has highest rate of reaction towards $\text{S}_{\text{N}}2$.
Hence, the order of rate of reaction is $\text{S} > \text{P} > \text{R} > \text{Q}$.

2. (b)



4. (c)

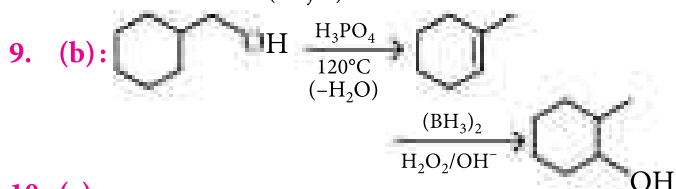
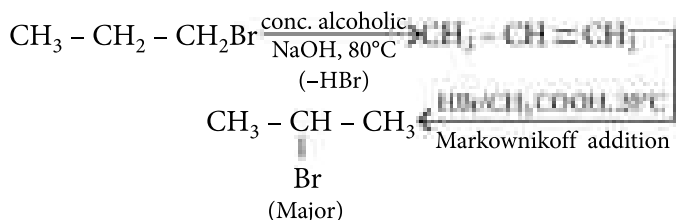


In the given compound, π -bonds and lone pair of oxygen atom are in conjugation. Structures (a), (b) and (d) represent the true resonating structures whereas in structure (c), separation of charge is not complete and highly electronegative oxygen atom carries positive charge.

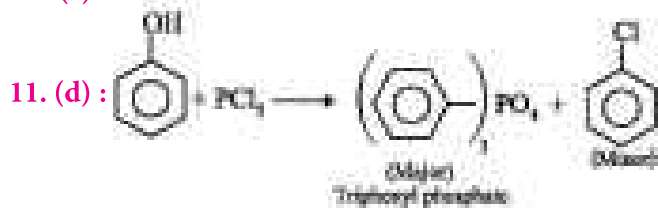
6. (c) : Acrolein has a pungent suffocating odour. It can be used to test glycerol's presence.

7. (b)

8. (b) :



10. (c)

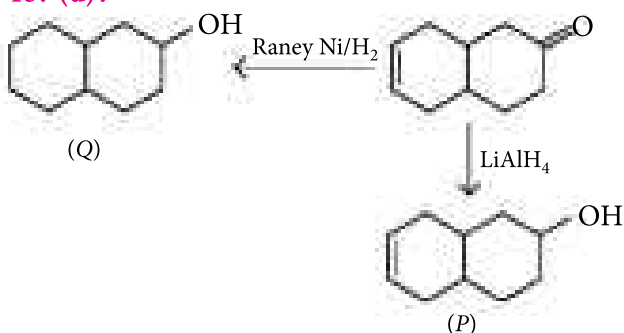


12. (c)

13. (b)

14. (d)

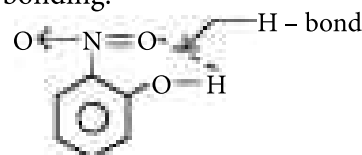
15. (d) :



16. (d)

17. (a)

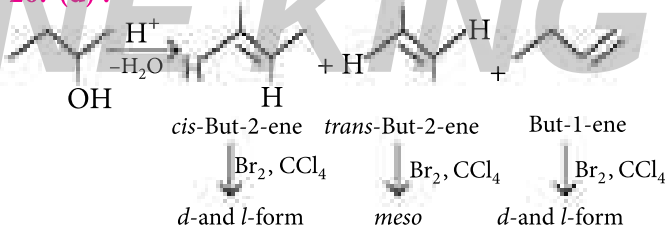
18. (a) : *o*-Nitrophenol is stable due to intramolecular hydrogen bonding.



It is difficult to break the H-bonding when dissolved in water, thus it is less soluble.

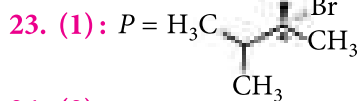
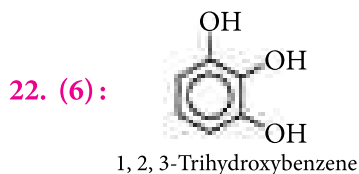
19. (d)

20. (d) :

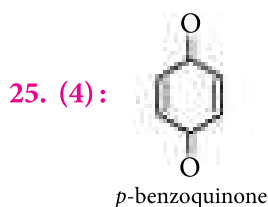


Thus, there can be 3 possible structures of *E*.

21. (5)



24. (3)





CBSE warm-up!

CLASS-XII

Chapterwise practice questions for CBSE Exams as per the latest pattern
and rationalised syllabus by CBSE for the academic session 2023-24.

Series-5

Coordination Compounds

Time Allowed : 3 hours
Maximum Marks : 70

General Instructions

Read the following instructions carefully.

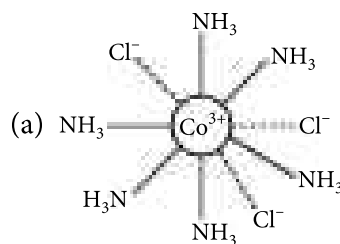
- There are 33 questions in this question paper with internal choice.
- SECTION-A consists of 16 multiple-choice questions carrying 1 mark each.
- SECTION-B consists of 5 short answer questions carrying 2 marks each.
- SECTION-C consists of 7 short answer questions carrying 3 marks each.
- SECTION-D consists of 2 case-based questions carrying 4 marks each.
- SECTION-E consists of 3 long answer questions carrying 5 marks each.
- All questions are compulsory.
- Use of log tables and calculators is not allowed.

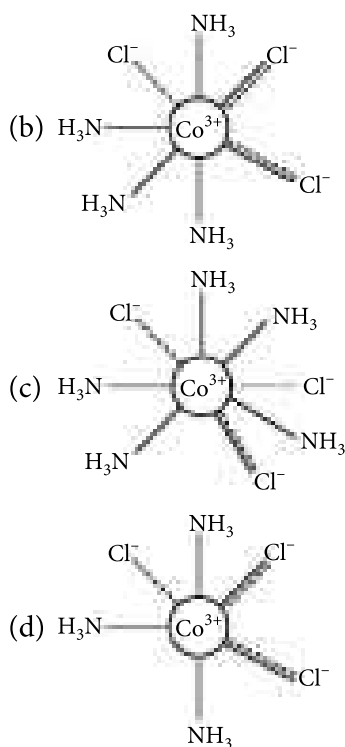
SECTION-A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

- The crystal field splitting energy for octahedral (Δ_o) and tetrahedral (Δ_t) complexes is related as
 - $\Delta_t = \frac{2}{9} \Delta_o$
 - $\Delta_t = \frac{5}{9} \Delta_o$
 - $\Delta_t = \frac{4}{9} \Delta_o$
 - $\Delta_t = 2\Delta_o$
- Which of the following options is incorrect?
 - $[\text{Ni}(\text{CO})_4]$: Tetrahedral, paramagnetic
 - $[\text{Ni}(\text{CN})_4]^{2-}$: Square planar, diamagnetic
 - $[\text{Ni}(\text{CO})_4]$: Tetrahedral, diamagnetic
 - $[\text{NiCl}_4]^{2-}$: Tetrahedral, paramagnetic
- t_{2g} consists of orbitals
 - $d_{xz}, d_{x^2-y^2}$
 - $d_{z^2}, d_{x^2-y^2}$
 - d_{xy}, d_{xz}, d_{yz}
 - $d_{xy}, d_{x^2-y^2}$

- Ambidentate ligands like NO_2^- and SCN^- are
 - unidentate
 - didentate
 - polydentate
 - None of these
- The formula of the coordination compound tetraamminechloridonitrito-N-cobalt(III) chloride is
 - $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{ONO})]\text{Cl}_2$
 - $[\text{Co}(\text{NH}_3)_4\text{Cl}_2(\text{NO}_2)]\text{Cl}$
 - $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$
 - $[\text{Co}(\text{NH}_3)_4(\text{NO}_2)]\text{Cl}_3$
- Which of the following complexes (Werner presentation) has minimum electrical conductance in aqueous solution?





7. What will be spin only magnetic moment of $[\text{NiCl}_4]^{2-}$

- (a) $\sqrt{8}$ B.M. (b) $\sqrt{15}$ B.M.
(c) $\sqrt{24}$ B.M. (d) $\sqrt{35}$ B.M.

8. Which of the following complex compounds is a poor electrolytic conductor in solution?

- (a) $\text{K}_2[\text{PtCl}_6]$ (b) $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$
(c) $\text{K}_4[\text{Fe}(\text{CN})_6]$ (d) $[\text{Co}(\text{NH}_3)_4]\text{SO}_4$

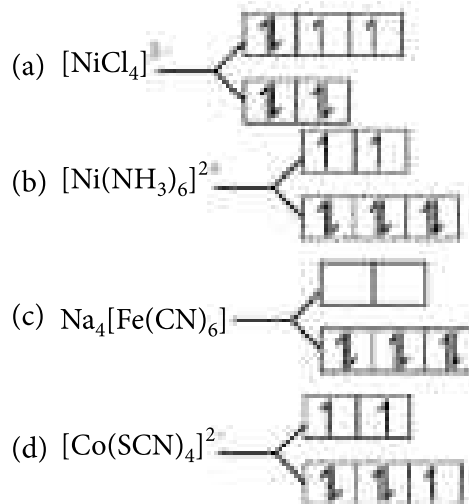
9. The pair $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$ and $[\text{Co}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$ will show

- (a) linkage isomerism
(b) hydrate isomerism
(c) ionisation isomerism
(d) coordinate isomerism.

10. Which of the following is correct for both the following coordination compounds?

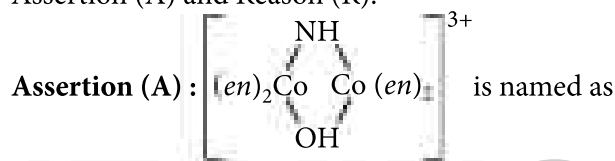
- I. $\text{CoCl}_3 \cdot 6\text{NH}_3$ II. $\text{PtCl}_4 \cdot 5\text{NH}_3$
(a) They give white precipitate with AgNO_3 solution
(b) They have different primary valencies for the central metal ions
(c) Both (a) and (b)
(d) None of these

11. Which of the following is incorrect distribution of electron in d -orbitals of metal in corresponding complex?



12. The ligand that shows synergic effect is
(a) H_2O (b) NH_3 (c) CO (d) $\text{C}_5\text{H}_5\text{N}$

13. Given below are two statements labelled as Assertion (A) and Reason (R).



tetrakis-(ethylenediamine)-μ-hydroxo-imido dicobalt (III) ion.

Reason (R) : In naming polynuclear complexes i.e., containing two or more metal atoms joined by bridging ligands, the word μ is added with hyphen before the name of such ligands.

Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

14. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ is coloured while $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$ is colourless

Reason (R) : $d-d$ -transition is not possible in $[\text{Sc}(\text{H}_2\text{O})_6]^{3+}$

Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

15. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : In high spin complex, configuration of d^5 ions will be $t_{2g}^3 e_g^2$.

Reason (R) : In high spin complex, pairing energy is less than crystal field energy.

Select the most appropriate answer from the options given below:

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

16. Given below are two statements labelled as Assertion (A) and Reason (R).

Assertion (A) : $[\text{Cu}(\text{NH}_3)_4]^{2+}$ is coloured while $[\text{Cu}(\text{CN})_4]^{3-}$ ion is colourless.

Reason (R) : $[\text{Cu}(\text{NH}_3)_4]^{2+}$ has dsp^2 hybridisation. Select the most appropriate answer from the options given below :

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

SECTION-B

This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

17. Explain the following, giving appropriate reasons:

- (a) $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ and $[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$ differ in their electrolytic conductance.
- (b) The value of molar conductivity of the aqueous solution of $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$ is zero.

18. How many stereoisomers of compound $[\text{CrCl}_2(\text{ox})_2]^{3-}$ are possible?

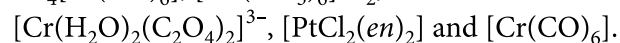
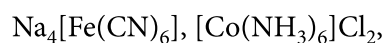
19. Explain giving an example: Formation of a coordination compound can be looked upon as the Lewis acid-base interaction.

20. Give reason: $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$ is a cationic complex while $\text{K}_3[\text{Fe}(\text{CN})_6]$ is an anionic complex.

21. Explain with examples homoleptic and heteroleptic complexes.

OR

Classify the complexes, as cationic, anionic or neutral.



SECTION-C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

- 22. (i) Draw enantiomers of $[\text{Cr}(\text{ox})_3]^{3-}$.
(ii) Draw enantiomers and *cis* and *trans* isomers of $[\text{Cr}(\text{H}_2\text{O})_2(\text{ox})_2]^-$ (where $\text{ox} = \text{C}_2\text{O}_4^{2-}$)
- 23. (a) Predict whether the $[\text{Cr}(\text{en})_2(\text{H}_2\text{O})_2]^{3+}$ complex is chiral. Write structure of its enantiomers.
(b) Draw one of the geometrical isomers of the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ which is optically active.
- 24. Out of $[\text{CoF}_6]^{3-}$ and $[\text{Co}(\text{en})_3]^{3+}$, which one complex is
(i) paramagnetic (ii) more stable
(iii) inner orbital complex and (Atomic no. of Co = 27)
- 25. Write the steps used to understand metal ligand bonding in coordination complexes using valence bond theory.

OR

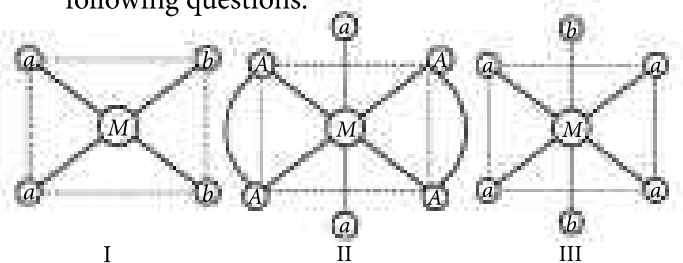
Answer the following questions :

- (a) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}_{(\text{aq})}$ is green in colour whereas $[\text{Ni}(\text{H}_2\text{O})_4(\text{en})]^{2+}_{(\text{aq})}$ is blue in colour, give reason in support of your answer.
- (b) Write the formula and hybridisation of the following compound :
tris(ethane-1,2-diamine)cobalt(III) sulphate
- 26. Write the IUPAC name of the following :
(a) $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ (b) $[\text{NiCl}_4]^{2-}$
(c) $\text{K}_3[\text{Fe}(\text{CN})_6]$
- 27. Explain structure and physical properties of *cis-trans* isomers in square planar complexes.
- 28. Give three drawbacks of Werner's Theory?

SECTION-D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

29. Study the complexes given below and answer the following questions.



Here, *a* and *b* are monodentate ligands while *AA* is a bidentate ligand.

Answer the following questions :

- (a) Will complex (I) exhibit geometrical isomerism?

OR

Will complex (II) exhibit geometrical isomers?

- (b) Draw *cis* isomer of complex (III).
(c) Is complex (III) optically active? Justify your answer.

30. Coordination compounds are formulated and named according to the IUPAC system.

Few rules for naming coordination compounds are :

- In ionic complex, the cation is named first and then the anion.
- In the coordination entity, the ligands are named first and then the central metal ion.
- When more than one type of ligands are present, they are named in alphabetical order of preference without any consideration of charge.

Answer the following questions :

- (a) Write the IUPAC name of the complex $[\text{Pt}(\text{NH}_3)_3\text{Br}(\text{NO}_2)\text{Cl}]\text{Cl}$.
(b) What is the IUPAC name of $[\text{Ni}(\text{CO})_4]$?
(c) Write the name and draw the structures of each of the following complex compounds :
(i) $[\text{Co}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{Cl}_3$
(ii) $[\text{Pt}(\text{NH}_3)_4][\text{NiCl}_4]$

OR

Using the IUPAC norms, write the systematic name of following :

- (i) $[\text{CoCl}(\text{NO}_2)(\text{NH}_3)_4]\text{Cl}$
(ii) $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$

SECTION-E

The following questions are long answer type and carry 5 marks each. All questions have an internal choice.

31. Attempt **any five** out of the following :

- (a) What is meant by chelate effect?
(b) NH_2NH_2 although possesses two electron pairs for donation but not acts as chelating agent.

- (c) What type of isomerism is shown by the complex $[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$?

- (d) What type of isomerism is shown by the complex $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$?

- (e) Write the coordination number and oxidation state of platinum in the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]$.

- (f) Which of the following is more stable complex and why? $[\text{Co}(\text{NH}_3)_6]^{3+}$ and $[\text{Co}(\text{en})_3]^{3+}$

- (g) What type of isomerism is shown by the complex $[\text{Co}(\text{en})_2\text{Cl}_2]^+$? Name the structure of an isomer of this complex which is optically active.

- (h) Draw one of the geometrical isomers of the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ which is optically inactive.

32. (a) The hexaaquamanganese (II) ion contains five unpaired electrons while hexacyano ion contains only one unpaired electron. Explain using crystal field theory.

- (b) A metal complex having composition $\text{Cr}(\text{NH}_3)_4\text{Cl}_2\text{Br}$ has been isolated in two forms (A) and (B). The form (A) reacts with AgNO_3 to give a white precipitate, which is readily soluble in dilute aqueous ammonia, whereas (B) gives a pale yellow precipitate, soluble in concentrated ammonia. Identify (A) and (B) and write all the chemical equations.

OR

- (a) What are bidentate ligands? Explain with examples.

- (b) Explain the coordination sites of polydentate ligands taking an example of EDTA.

- (c) Calculate charge on the central metal in the following complexes:
(i) $[\text{Cu}(\text{NH}_3)_6]^{2+}$ (ii) $[\text{Ag}(\text{CN})_2]^-$

33. Write down the IUPAC name for each of the following complexes and indicate the oxidation state, electronic configuration and coordination number. Also give geometry and magnetic moment of the complexes :

- (a) $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2] \cdot 3\text{H}_2\text{O}$
(b) $[\text{CrCl}_3(\text{py})_3]$ (c) $\text{K}_4[\text{Mn}(\text{CN})_6]$
(d) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ (e) $\text{Cs}[\text{FeCl}_4]$

OR

- (a) Write the main assumptions of valence bond theory.

- (b) What do you mean by inner orbital complexes and outer orbital complexes? Give examples of each.

- (c) Find the geometry of $[\text{CrCl}_3(\text{py})_3]$ and $[\text{Ni}(\text{CO})_4]$.

SOLUTIONS

1. (c) 2. (a) 3. (c) 4. (a)

5. (c) : $[\text{Co}(\text{NH}_3)_4\text{Cl}(\text{NO}_2)]\text{Cl}$:

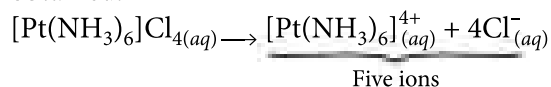
Tetraamminechloridonitrito-N-cobalt(III) chloride

6. (d) 7. (a) 8. (b)

9. (c) : The pair $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Br}_2$ and $[\text{Co}(\text{NH}_3)_4\text{Br}_2]\text{Cl}_2$ will show ionisation isomerism.

10. (c) 11. (d) 12. (c) 13. (d)
14. (a) 15. (c) 16. (b)

17. (a) When the aqueous solution of $[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$ gets ionised, one $[\text{Pt}(\text{NH}_3)_6]^{4+}$ ion and four Cl^- ions are obtained.

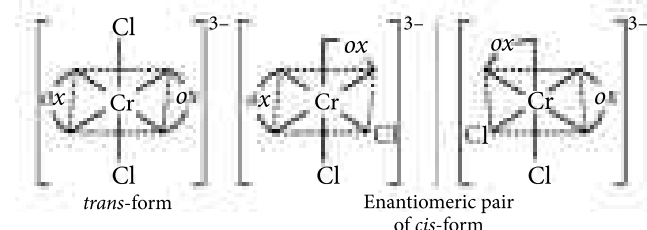


$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ is a non-ionisable complex, it does not give any ion.

Thus, $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$ has no molar conductance while $[\text{Pt}(\text{NH}_3)_6]\text{Cl}_4$ has a certain value of molar conductance.

(b) The given complex, $[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$ is a neutral, non-ionisable compound and hence, its aqueous solution does not undergo ionisation. Thus, this complex compound has no value of molar conductivity.

18. $[\text{CrCl}_2(\text{ox})_2]^{3-}$ can exist in *cis* and *trans*-form. *Cis*-form is optically active and thus exists in enantiomeric pair.



19. In a coordination compound, the ligands being electron pair donors are Lewis bases and central metal ion being electron pair acceptor serves as Lewis acid. For example, in cisplatin, $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$, two ammonia molecules and two chloride ligands utilize their lone pairs of electrons to form bonds with central metal ion, Pt(II) which is an electron deficient species.

The donor nitrogen and chlorine atoms of the ligands are directly attached to platinum and form bonds with platinum.

Hence, formation of a coordination compound can be looked upon as the Lewis acid-base interaction.

20. $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{SO}_4$ is a cationic complex because it has coordination sphere $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$. The anion SO_4^{2-} is a counter ion and makes the complex overall

neutral. $\text{K}_3[\text{Fe}(\text{CN})_6]$ is an anionic complex because it has anionic coordination sphere $[\text{Fe}(\text{CN})_6]^{3-}$. The three K^+ ions are counter ions and make the complex neutral overall.

21. Complexes in which metal is bound to only one kind of donor groups are known as homoleptic complexes. e.g. $[\text{Co}(\text{NH}_3)_6]^{3+}$.

Complexes in which metal is bound to more than one kind of donor groups are called heteroleptic complexes. e.g., $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$.

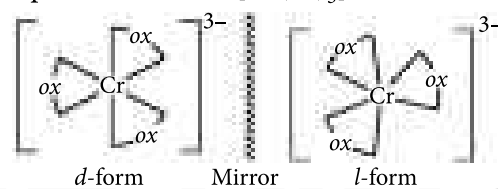
OR

(a) Cationic complexes : $[\text{Co}(\text{NH}_3)_6]\text{Cl}_2$

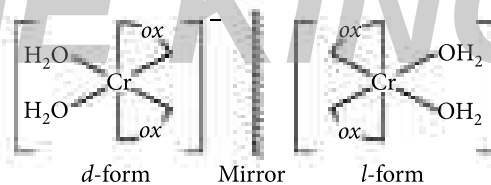
(b) Anionic complexes : $\text{Na}_4[\text{Fe}(\text{CN})_6]$, $[\text{Cr}(\text{H}_2\text{O})_2(\text{C}_2\text{O}_4)_2]^{3-}$

(c) Neutral complexes : $[\text{PtCl}_2(\text{en})_2]$, $[\text{Cr}(\text{CO})_6]$.

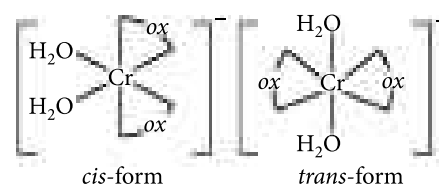
22 (i) Optical isomers of $[\text{Cr}(\text{ox})_3]^{3-}$:



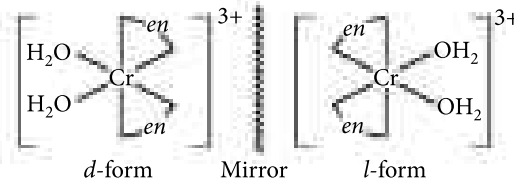
(ii) (a) Enantiomers of $[\text{Cr}(\text{H}_2\text{O})_2(\text{ox})_2]^-$



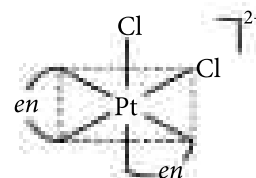
(b) *Cis* and *trans* isomers of $[\text{Cr}(\text{H}_2\text{O})_2(\text{ox})_2]^-$



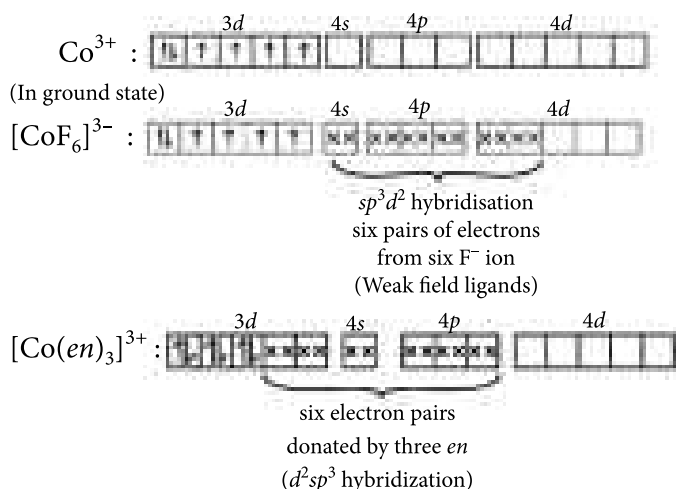
23. (a) The complex $[\text{Cr}(\text{en})_2(\text{H}_2\text{O})_2]^{3+}$ is chiral. Structures of enantiomers are as follows:



(b) *Cis*-isomer of the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]^{2+}$ is optically active.



24. Oxidation state of Co ion in $[\text{CoF}_6]^{3-}$ is +3.



- (i) $[\text{CoF}_6]^{3-}$ is paramagnetic in nature.
- (ii) Chelating ligands form more stable cyclic/ring complexes than unidentate or non-chelating ligands. Since, $[\text{Co(en)}_3]^{3+}$ contains *en* which is a bidentate chelating ligand, it is more stable than $[\text{CoF}_6]^{3-}$.
- (iii) $[\text{Co(en)}_3]^{3+}$ is an inner orbital complex as its hybridisation is d^2sp^3 .

25. Steps to understand metal-ligand bonding:

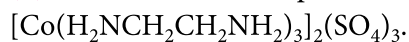
- (a) Find oxidation state of central metal ion.
- (b) Write valence shell electronic configuration of metal ion.
- (c) From the number of ligands, find the number of metal ion orbitals required for bonding.
- (d) See whether the complex is low spin or high spin. (Applicable only for octahedral complexes with d^4 to d^8 electronic configurations)
- (e) Write the electronic configuration after pairing.
- (f) Identify the orbitals of metal ion available for hybridisation and the type of hybridisation involved.
- (g) Show filling of orbitals after complex formation.
- (h) Determine the number of unpaired electrons and predict magnetic behaviour of the complex.

OR

(a) The colour of coordination compounds depends upon the type of ligands and $d-d$ transition taking place. H_2O is weak field ligand, which causes small splitting, leading to the $d-d$ transition corresponding green colour, however due to the presence of ethane-1,2-diamine (*en*) which is a strong field ligand, the splitting is increased.

Due to the change in $t_{2g} - e_g$ splitting the colouration of the compound changes from green to blue.

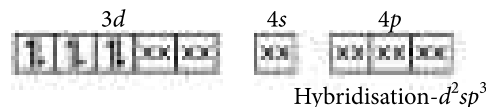
(b) Formula of the compound is



The hybridisation of the compound is d^2sp^3 .

Cobalt in this complex has an oxidation number of +3.

The electronic configuration of Co^{3+} : $3d^6 4s^0$ and *en* is a strong field ligand that will cause pairing of electrons in d -orbital of Co^{3+} .



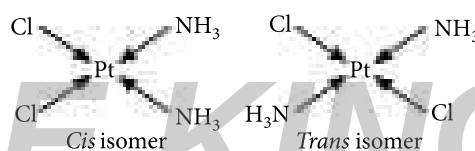
26. (a) Hexaamminecobalt(III) chloride

(b) Tetrachloridonickelate(II) ion

(c) Potassium hexacyanidoferrate(III)

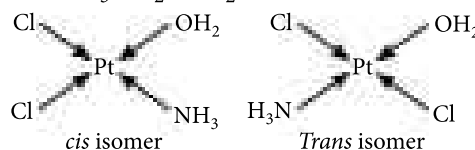
27. The square planar complexes of MA_2B_2 and MA_2BC types exist as *cis* and *trans* isomers, where A, B, and C are monodentate ligands, M is the central metal atom.

(i) *Cis-trans* isomerism in MA_2B_2 type complexes : e.g. $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$



- (a) The *cis* isomer is more soluble in water than the *trans* isomer.
- (b) The *cis* isomer named as *cis-platin* is an anticancer drug while the *trans* isomer is physiologically inactive.
- (c) The *cis* isomer is polar with non-zero dipole moment while the *trans* isomer has zero dipole moment as a result of the two opposite $\text{Pt}-\text{Cl}$ and two $\text{Pt}-\text{NH}_3$ bond moments, which cancel each other.

(ii) *Cis-trans* isomerism in MA_2BC type complexes : e.g. $[\text{Pt}(\text{NH}_3)(\text{H}_2\text{O})\text{Cl}_2]$



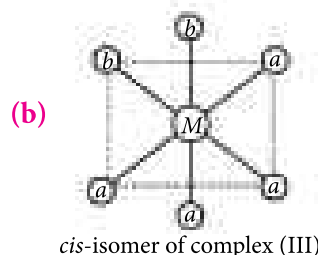
28. Drawbacks of Werner's Theory:

- (a) This theory could not explain the ability of only certain elements to form coordination compounds.
- (b) It fails to explain the directional properties of coordinate bonds in complexes.
- (c) It does not explain the presence of magnetic and optical properties in coordination compounds.

29. (a) Yes, complex (I) will exhibit geometrical isomerism.

OR

Yes, complex (II) will exhibit geometrical isomerism.



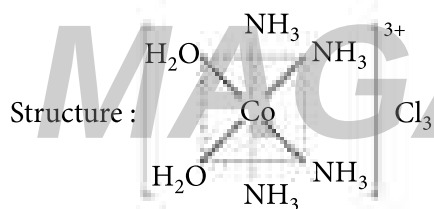
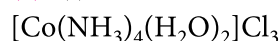
(c) No ; Complex (III) is optically inactive as it has a plane of symmetry.

30. (a) Ligands are named in an alphabetical order irrespective of their charge. The IUPAC name of the given complex is

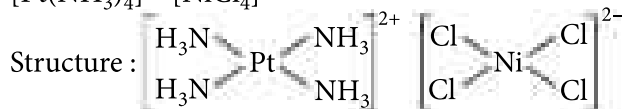
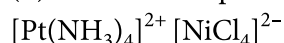
Triamminebromidochloridonitroplatinum(IV) chloride.

(b) Tetracarbonylnickel(0)

(c) (i) Tetraamminediaquacobalt (III) chloride



(ii) Tetraammineplatinum (II) tetrachloridonickelate(II)



OR

(i) Tetramminechloridonitrito-N-cobalt(III) chloride

(ii) Hexamminecobalt(III)hexacyanidochromate(III)

31. (a) When a didentate or polydentate ligand uses its two or more donor atoms to bind a single metal ion. It is said to be a chelate ligand. Chelating ligands form more stable complexes than monodentate analogs. This is called chelating effect.

(b) NH_2-NH_2 have two donor atoms, it can form three membered ring which is very strained, thus it can not act as chelating agent.

(c) Linkage isomerism is shown by the given complex as NO_2 is an ambidentate ligand. The resultant linkage isomers are $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5(\text{ONO})]\text{Cl}_2$.

Ionisation isomerism is also shown by the given complex as $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ and $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{NO}_2\text{Cl}$

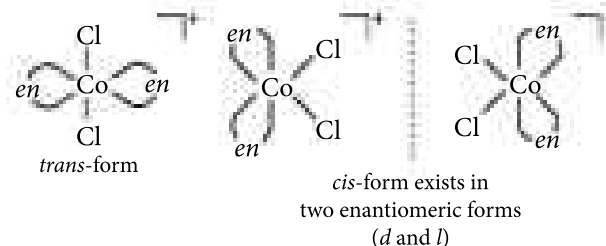
(d) Coordination isomerism

(e) Coordination number and oxidation state of Pt in the complex $[\text{Pt}(\text{en})_2\text{Cl}_2]$ are 6 and +2 because *en* is a bidentate and neutral ligand.

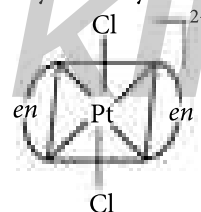
(f) $[\text{Co}(\text{en})_3]^{3+}$ is more stable complex than $[\text{Co}(\text{NH}_3)_6]^{3+}$ due to chelate effect as it forms rings.

(g) $[\text{CoCl}_2(\text{en})_2]^+$: Dichloridobis(ethane-1,2-diamine) cobalt(III) ion

This complex exhibits both optical and geometrical isomerism and *cis* isomer is optically active.



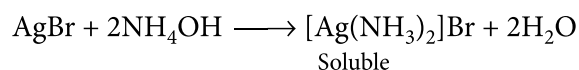
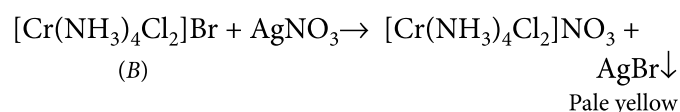
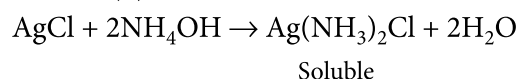
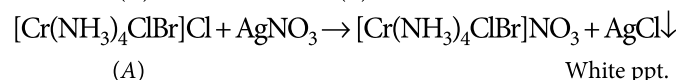
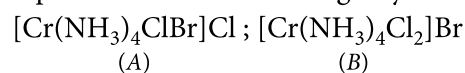
(h) *Trans*-isomer is optically inactive due to the presence of plane of symmetry.



32. (a) Mn in +2 oxidation state has the electronic configuration $3d^5$. H_2O is a weak ligand. In presence of H_2O molecules, the distribution of electrons is $t_{2g}^3 e_g^2$ i.e., all the electrons are unpaired.

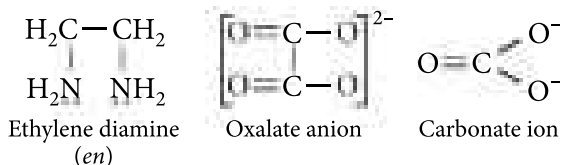
CN^- is a strong ligand. In its presence, the distribution of electrons is $t_{2g}^5 e_g^0$ i.e., one unpaired electron is present.

(b) Complex, $\text{Cr}(\text{NH}_3)_4\text{Cl}_2\text{Br}$, has two isomers. Since, coordination number of Cr is six, the two forms may be represented in the following way :



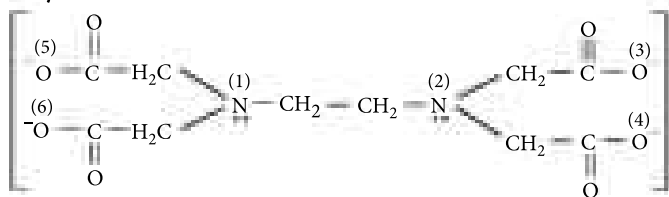
OR

(a) Ligands which can coordinate with the central metal atom or ion through two donor atoms are known as bidentate ligands. Examples of bidentate ligands are:



(b) Ligands which coordinate with the central ion through more than two donor atoms present in the molecule are called polydentate ligands. These are tridentate(three), tetradentate(four), pentadentate(five) and hexadentate (six) ligands depending upon the number of coordinating donor atoms present in their

molecules. A common example of hexadentate ligand is ethylenediaminetetraacetate ion as shown below:



(c) The charge carried by a complex ion is the algebraic sum of charges carried by the central metal ion and the ligands coordinated to it.

- (i) $[\text{Cu}(\text{NH}_3)_6]^{2+}$ carries a charge of +2 because Cu^{2+} carries a charge of +2 and ammonia molecule is neutral.
(ii) $[\text{Ag}(\text{CN})_2]^-$ ion carries a charge of -1 because Ag carries a charge of +1 and two cyanide ions coordinated to it carry a charge of -1 each.

33.

Complex and IUPAC name	Oxidation state of central metal ion/ atom	Electronic configuration of central metal ion/atom (outer)	Coordination number
(a) $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2] \cdot 3\text{H}_2\text{O}$ Potassium diaqua bis (oxalato) chromate(III) trihydrate	+3	$3d^3$ or t_{2g}^3	6
(b) $[\text{CrCl}_3(\text{py})_3]$ Trichloridotripyridinechromium(III)	+3	$3d^3$ or t_{2g}^3	6
(c) $\text{K}_4[\text{Mn}(\text{CN})_6]$ Potassium hexacyanidomanganate(II)	+2	$3d^5$ or t_{2g}^5	6
(d) $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ Pentaamminechloridocobalt(III) chloride	+3	$3d^6$ or t_{2g}^6	6
(e) $\text{Cs}[\text{FeCl}_4]$ Caesium tetrachloridoferrate(III)	+3	$3d^5$ or $e^2 t_2^3$	4

OR

(a) This theory is given by Pauling. The main assumptions of this theory are as follows :

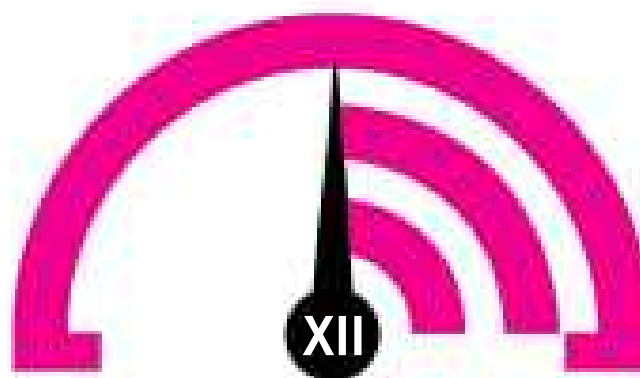
- (i) The empty s , p and d atomic orbitals equal to the coordination number of central metal ion, are made available by the central metal atom or ion. The vacant orbitals get hybridized to produce equal number of hybridized orbitals of same energy and shape which are arranged in definite geometry.
(ii) The ligand molecules must have at least one σ -orbital containing a lone pair of electrons.
(iii) These σ -orbitals (containing lone pairs) of ligand are overlapped by the vacant hybridized orbitals of metal atoms or ions to form ligand $\rightarrow$ Metal σ -bond (coordinate bond).

(b) If the d -orbitals used in the hybridization (d^2sp^3) are of lower shell than the s - and p - orbitals i.e., $(n-1)d$ then the complexes formed are called inner orbital or low spin complexes. For example in $\text{K}_4[\text{Fe}(\text{CN})_6]$, $3d$, $4s$ and $4p$ orbitals take part in hybridization, therefore, it is an inner orbital complex.

If the d -orbitals used in the hybridization (sp^3d^2) are of the same principal energy level as that of s - and p -orbitals, the complexes are called outer orbital complexes or high spin complexes. For example in $[\text{FeF}_6]^{3-}$, $4s$, $4p$ and $4d$ orbitals take part in hybridization, therefore, it is an outer orbital complex.

(c) Geometry of $[\text{CrCl}_3(\text{py})_3]$ is octahedral and the geometry of $[\text{Ni}(\text{CO})_4]$ is tetrahedral.

MONTHLY TEST DRIVE



This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Electrochemistry | Chemical Kinetics

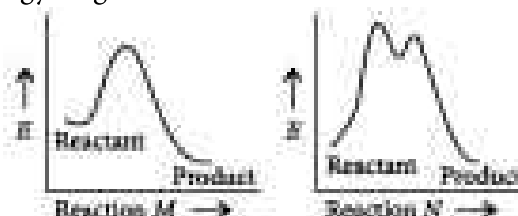
Time Taken : 60 Min.

NEET

Only One Option Correct Type

- To find the standard potential of M^{3+}/M electrode, the following cell is constituted :
 $\text{Pt} | M | M^{3+} (0.001 \text{ mol L}^{-1}) || \text{Ag}^+ (0.01 \text{ mol L}^{-1}) | \text{Ag}$
 The emf of the cell is found to be 0.421 V at 298 K. The standard potential of half cell reaction $M^{3+} + 3e^- \rightarrow M$ at 298 K will be
 (Given : $E^\circ_{\text{Ag}^+/\text{Ag}}$ at 298 K = 0.80 V)
 (a) 0.32 V (b) 0.66 V
 (c) 0.38 V (d) 1.28 V
- In a chemical reaction $A + 2B \rightarrow \text{products}$, when concentration of A is doubled, rate of the reaction increases 4 times and when concentration of B alone is doubled, the rate continues to be the same. The order of the reaction is
 (a) 1 (b) 2 (c) 3 (d) 4
- The Gibbs energy for the decomposition of Al_2O_3 at 500°C is as follows : $\frac{2}{3} \text{Al}_2\text{O}_3 \rightarrow \frac{4}{3} \text{Al} + \text{O}_2$
 $\Delta_r G = +960 \text{ kJ mol}^{-1}$
 The potential difference needed for the electrolytic reduction of aluminium oxide (Al_2O_3) at 500°C is at least
 (a) 4.5 V (b) 3.0 V (c) 2.5 V (d) 5.0 V
- Which one of the following equations is correct for the reaction, $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$?
 (a) $\frac{3d[\text{H}_2]}{dt} = \frac{2d[\text{N}_2]}{dt}$ (b) $\frac{2d[\text{N}_2]}{dt} = \frac{1}{3} \frac{d[\text{H}_2]}{dt}$
 (c) $\frac{2d[\text{NH}_3]}{dt} = \frac{-3d[\text{H}_2]}{dt}$ (d) $\frac{3d[\text{NH}_3]}{dt} = \frac{-2d[\text{H}_2]}{dt}$

- Indicator electrode is
 (a) SHE (b) calomel electrode
 (c) Ag/AgCl electrode (d) quinhydrone electrode.
- The rate constant of a reaction is $3.00 \times 10^3 \text{ L mol}^{-1} \text{ sec}^{-1}$. The order of this reaction will be
 (a) zero (b) first
 (c) second (d) third.
- A current of 3.86 A was passed through molten calcium oxide for 41 minutes and 40 seconds. The mass of calcium in grams deposited at the cathode is (Atomic mass of Ca is 40 g/mol, $1 \text{ F} = 96500 \text{ C}$)
 (a) 4 (b) 2 (c) 6 (d) 8
- The correct statement regarding the following energy diagrams is



- reaction M is faster and less exothermic than reaction N
 - reaction M is slower and less exothermic than reaction N
 - reaction M is faster and more exothermic than reaction N
 - reaction M is slower and more exothermic than reaction N.
- The approximate time duration in hours to electroplate 30 g of calcium from molten calcium chloride using a current of 5 A is
 [At. mass of Ca = 40]
 (a) 8 (b) 80 (c) 10 (d) 16

10. Activation energy (E_a) and rate constants (k_1 and k_2) of a chemical reaction at two different temperatures (T_1 and T_2) are related by

(a) $\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$

(b) $\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$

(c) $\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_2} + \frac{1}{T_1} \right)$

(d) $\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{1}{T_1} + \frac{1}{T_2} \right)$

11. At 25 °C, the molar conductance of 0.007 M hydrofluoric acid is 150 mho cm² mol⁻¹ and its Λ_m° is 500 mho cm² mol⁻¹. The value of the dissociation constant of the acid at the given concentration at 25 °C is

- (a) 7×10^{-4} M (b) 7×10^{-5} M
(c) 9×10^{-3} M (d) 9×10^{-4} M

12. The specific rate constant of a first order reaction depends on the

- (a) concentration of the reactant
(b) concentration of the product
(c) time (d) temperature.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

- (a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** A catalyst increases the rate of reaction without itself undergoing any permanent chemical change.

Reason : A catalyst changes the Gibbs energy (ΔG) of the reaction and equilibrium constant of the reaction.

14. **Assertion :** For a first order reaction, $t_{1/2}$ is independent of rate constant.

Reason : For a first order reaction, $t_{1/2} \propto [R]_0$.

15. **Assertion :** Lithium has the lowest electrode potential.

Reason : Lithium ion is the strongest oxidising agent.

JEE (Main & Advanced)

Only One Option Correct Type

16. For the following electrochemical cell at 298 K, $\text{Pt}_{(s)} | \text{H}_{2(g)} (1 \text{ bar}) | \text{H}^+_{(aq)} (1 \text{ M}) || \text{M}^{4+}_{(aq)}, \text{M}^{2+}_{(aq)} | \text{Pt}_{(s)}$

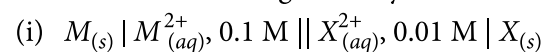
$$E_{\text{cell}} = 0.092 \text{ V when } \frac{[\text{M}^{2+}_{(aq)}]}{[\text{M}^{4+}_{(aq)}]} = 10^x$$

Given : $E^\circ_{\text{M}^{4+}/\text{M}^{2+}} = 0.151 \text{ V}$; $2.303 \frac{RT}{F} = 0.059 \text{ V}$

The value of x is

- (a) -2 (b) -1 (c) 1 (d) 2

17. Consider the following electrolytic cells :



The cell EMF of the above cells are E_1 , E_2 and E_3 respectively, which one of the following is true?

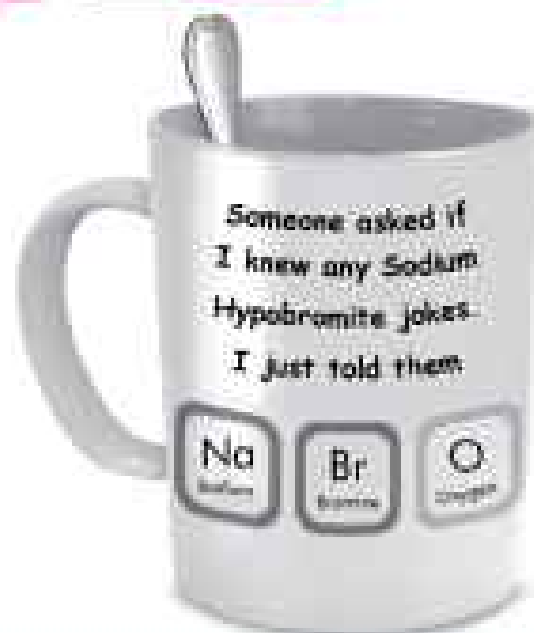
- (a) $E_1 > E_2 > E_3$ (b) $E_2 > E_3 > E_1$
(c) $E_3 > E_1 > E_2$ (d) $E_3 > E_2 > E_1$

18. The rate of a reaction A doubles on increasing the temperature from 300 K to 310 K. By how much, the temperature of reaction B should be increased from 300 K so that rate doubles if activation energy of the reaction B is twice to that of reaction A.

- (a) 19.67 K (b) 9.84 K
(c) 2.45 K (d) 4.92 K



CHEM CAPSULE



- ### More than One Option Correct Type

- (c) the time taken for the completion of 75% reaction is thrice the $t_{1/2}$ of the reaction
(d) the pre-exponential factor in the Arrhenius equation has the dimension of time inverse, t^{-1} .

24. For the electrochemical cell,
 $\text{Mg}_{(s)} \mid \text{Mg}^{2+} (aq, 1 \text{ M}) \parallel \text{Cu}^{2+} (aq, 1 \text{ M}) \mid \text{Cu}_{(s)}$
 the standard emf of the cell is 2.70 V at 300 K. When the concentration of Mg^{2+} is changed to x M, the cell potential changes to 2.67 V at 300 K. The value of x is _____. (Given, $F/R = 11500 \text{ K V}^{-1}$, where F is the Faraday constant and R is the gas constant, $\ln(10) = 2.30$)

25. An organic compound undergoes first-order decomposition. The time taken for decomposition to $1/8^{\text{th}}$ and $1/10^{\text{th}}$ of its initial concentration are $t_{1/8}$ and $t_{1/10}$ respectively. What is the value of $\frac{[t_{1/8}]}{[t_{1/10}]}$ $\times 10$? (take $\log_{10} 2 = 0.3$)

Winners : Kaushikkumar Kevadiya, Ankit Sharma, Diya Kapoor, Krati Trigunait

SOLUTIONS TO AUGUST 2023 WORD GRID

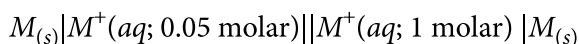
G	Y	E	X	U	I	I	I	I	I	E	S	P	U	D
F	L	E	C	T	G	U	A	I	O	L	Y	I	S	
A	W	R	R	B	S	T	U	V	P	O	C	N	T	
N	I	I	I	I	I	I	I	I	I	I	I	I	A	
B	T	A	O	Q	H	A	B	A	M	R	P	U	U	
C	V	M	D	N	O	R	T	C	X	O	T	W	P	
O	W	A	E	G	S	C	Q	C	O	Z	S	I	O	
P	P	L	P	E	P	H	N	H	R	Y	T	I	N	
Q	B	G	O	A	H	L	B	A	W	X	S	I	Z	
A	S	A	N	O	A	U	O	R	U	V	T	I	G	
N	O	M	W	A	T	V	E	I	S	W	S	I	R	H
B	V	P	V	N	R	O	C	K	E	B	J	O	W	W
O	C	T	I	I	I	I	I	I	I	I	I	I	X	A
S	T	O	I	P	A	E	K	O	R	W	Q	X	U	O
F	N	T	S	M	I	S	C	I	B	I	L	I	Y	N
M	I	I	I	I	I	I	I	I	I	I	I	I	N	R
O	R	W	A	E	Z	W	C	Q	C	O	Z	S	I	O
A	R	I	I	I	I	I	I	I	O	R	U	V	T	E

- | | |
|----------------|--------------|
| 1. Hemocyanin | 5. Pyranose |
| 2. Methylation | 6. Submicron |
| 3. Nitrosyls | 7. Wolfram |
| 4. Occlusion | 8. Zymase |

26. All the energy released from the reaction $X \rightarrow Y$, $\Delta_r G^\circ = -193 \text{ kJ mol}^{-1}$ is used for oxidizing M^+ as $M^+ \rightarrow M^{3+} + 2e^-$, $E^\circ = -0.25 \text{ V}$. Under standard conditions, the number of moles of M^+ oxidized when one mole of X is converted to Y is _____. [$F = 96500 \text{ C mol}^{-1}$]

Comprehension Type

The concentration of potassium ions inside a biological cell is at least twenty times higher than the outside. The resulting potential difference across the cell is important in several processes such as transmission of nerve impulses and maintaining the ion balance. A simple model for such a concentration cell involving a metal M is:



For the above electrolytic cell, the magnitude of the cell potential $|E_{\text{cell}}| = 70 \text{ mV}$.

27. Select the correct option regarding the above cell.
 (a) $E_{\text{cell}} < 0$; $\Delta G > 0$ (b) $E_{\text{cell}} > 0$; $\Delta G < 0$
 (c) $E_{\text{cell}} < 0$; $\Delta G^\circ > 0$ (d) $E_{\text{cell}} > 0$; $\Delta G^\circ > 0$
28. If the 0.05 molar solution of M^+ is replaced by a 0.0025 molar M^+ solution, then the magnitude of the cell potential would be
 (a) 35 mV (b) 70 mV
 (c) 153 mV (d) 700 mV.

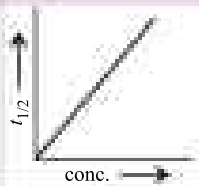
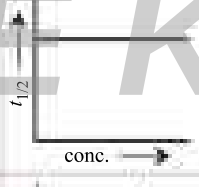
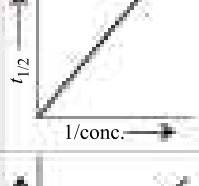
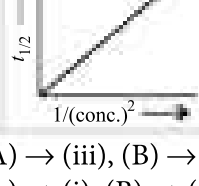
Matching Type

29. An aqueous solution of X is added slowly to an aqueous solution of Y as shown in Column I. The variation in conductivity of these reactions is given in Column II. Match Column I with Column II and mark the appropriate choice.

	Column I		Column II
P.	$(\text{C}_2\text{H}_5)_3\text{N} + \text{CH}_3\text{COOH}$ (X) (Y)	1.	Conductivity decreases and then increases.
Q.	$\text{KI} (0.1\text{M}) + \text{AgNO}_3$ (X) (Y) (0.01 M)	2.	Conductivity decreases and then does not change much.

R.	$\text{CH}_3\text{COOH} + \text{KOH}$ (X) (Y)	3.	Conductivity increases and then does not change much.
S.	$\text{NaOH} + \text{HI}$ (X) (Y)	4.	Conductivity does not change much and then increases.

- (a) (P) $\rightarrow$ (3), (Q) $\rightarrow$ (4), (R) $\rightarrow$ (2), (S) $\rightarrow$ (1)
 (b) (P) $\rightarrow$ (4), (Q) $\rightarrow$ (3), (R) $\rightarrow$ (2), (S) $\rightarrow$ (1)
 (c) (P) $\rightarrow$ (2), (Q) $\rightarrow$ (3), (R) $\rightarrow$ (4), (S) $\rightarrow$ (1)
 (d) (P) $\rightarrow$ (1), (Q) $\rightarrow$ (4), (R) $\rightarrow$ (3), (S) $\rightarrow$ (2)
30. Match the plots in column I with their orders in column II and mark the appropriate choice.

	Column I		Column II
(A)		(i)	Zero order
(B)		(ii)	First order
(C)		(iii)	Second order
(D)		(iv)	Third order

- (a) (A) $\rightarrow$ (iii), (B) $\rightarrow$ (ii), (C) $\rightarrow$ (i), (D) $\rightarrow$ (iv)
 (b) (A) $\rightarrow$ (i), (B) $\rightarrow$ (ii), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (iv)
 (c) (A) $\rightarrow$ (iv), (B) $\rightarrow$ (iii), (C) $\rightarrow$ (ii), (D) $\rightarrow$ (i)
 (d) (A) $\rightarrow$ (ii), (B) $\rightarrow$ (i), (C) $\rightarrow$ (iii), (D) $\rightarrow$ (iv)

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted
 No. of questions correct
 Marks scored in percentage

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.



Unlock Your Knowledge!



1. A compound of silver which is an important component of photographic film is _____.
2. Sphalerite is an ore of _____.
3. The central metal atom present in chlorophyll is _____.
4. The method of purification used for separation of an organic compound from its aqueous solution by shaking with suitable solvent is termed as _____.
5. Gutta-percha is a polymer of _____ monomer.
6. Hinsberg reagent is _____.
7. The compounds which are used to reduce the body temperature during fever are _____.
8. Pellagra is caused due to deficiency of _____.
9. Amylose gives _____ coloured complex with I_2 due to the formation of an inclusion complex.
10. The reaction in which tertiary alcohols on treatment with HCN in presence of concentrated H_2SO_4 form the corresponding primary amine is termed as _____ reaction.
11. Blue colour is shown by _____ alcohols during Victor Meyer's test.
12. The alcohols are converted to aldehydes and ketones by the process of _____.
13. The IUPAC name of $K_2[PtCl_6]$ is _____.
14. Bronze is an alloy of _____ and _____.
15. Euchlorine is a mixture of _____ and _____.
16. SnO is a/an _____ oxide.
17. The alkaline earth metal which gives apple-green coloured flame is _____.
18. The sulphide ore of lead is named as _____.
19. Electricity produced due to placement of ions from their orderly arrangement by applying mechanical stress is _____.
20. Packing efficiency of simple cubic unit cell is _____%.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.



Here are the nine shuffled words containing 3 sets of trio. The three letters of trio can be arranged in any sequence. Complete these words by finding 3 sets of trio.

_ _ _ _ CINATION
 _ _ _ _ RAHEDRON
 MO _ _ _ _ ULE
 _ _ _ _ TONE
 BURE _ _ _ _
 PARTI _ _ _ _
 _ _ _ _ OHOL
 PIP _ _ _ _ E
 MI _ _ _ _ LE

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UCD

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B.Tech. Metallurgical Engineering

B.Tech. Metallurgical Engineering is an undergraduate course and the duration of this course is four years. This course offers in-depth study of the fundamentals of Metallurgical Engineering principles. The course covers studies related to mining, extraction, processing and designing of metals. It involves theory and practical study on the science and technology that focus on working and heat-treating metals and alter their physical characteristics. The course also offers the studies related to the separation of metals from their ores, making and compounding of alloys etc. The candidates who have interest in various features of metallurgy and material sciences can opt for this course, as the course provides multiple placement opportunities in various public as well as private sectors.

Eligibility

Admission to the course of B.Tech. in Metallurgical Engineering requires the eligible candidates to pass Class 12th with subjects like physics, chemistry and mathematics from a recognised board with a minimum aggregate of 55% marks.

Entrance Exams

- JEE Main
- MHT CET
- WBJEE
- KEAM
- VITEEE

Career

Metallurgical jobs are one of the most desired jobs in India. Metallurgists are employed in foundries, heat treatment shops, rolling mills, etc. They are also employed in research laboratories, industries and plants extracting and processing metals like iron and steel, nickel, tin, copper, zinc, aluminium, and brass etc. Metal extractors like Tata Steel, Steel Authority of India (SAIL), Hindustan Copper Limited, Hindalco Industries Limited, and Jindal Steel are the major recruiters of metallurgical consultants. The various job duties of a metallurgical engineer are listed below:

- Conducting research and development
- Supervision of production processes
- Developing processing plants
- Sale and services of metal products
- Assurance of the quality of metal products
- Write for technical magazines and trade associations

Metallurgical engineers can also supervise the work of metallographers, highly trained technologists, and other assistants in conducting tests on metals to determine their structure for such purposes as quality control, the development of new and improved alloys, and the development of better production methods. Hence, the various roles in which a metallurgical engineer can be hired are:

- Project Engineer
- Research Assistant
- Metallurgy Engineer
- Project Manager
- Assistant Engineer

Top Colleges

- **Indian Institute of Technology (BHU), Varanasi**
- National Institute of Technology, Tiruchirappalli (Metallurgical and Material Engineering)
- Indus University, Ahmedabad
- PEC University of Technology, Chandigarh (Metallurgical and Material Engineering)



Indian Institute of Technology (BHU), Varanasi

The department of metallurgical engineering of the college is currently offering Bachelor, Master and Doctoral degree programmes. It had been recognised as Centre of Advanced Study in 1980 and presently running into the IVth phase of this status. The members of staff have been actively engaged in research and have undertaken many research/consultancy projects. These research activities span over wide ranging fields of nanomaterials characterisation, quasicrystals, biomaterials, magnetic materials, spray forming, rapid solidification, mechanical alloying, powder metallurgy, modeling of phase diagram by CVM, phase transformation in steels and non-ferrous alloys and structure property correlations, creep and fatigue behaviour of materials, nanoindentation, corrosion, thermodynamics of alloys and semiconducting intermetallics, pyrometallurgy of sulphide minerals, preparation of molycarbides, processing of ferrous and non-ferrous alloys, foundry and welding, wear studies of composites, waste utilisation and energy management etc. The placements from this college are really good and students get placed in various renowned companies after completing this course.

WHAT IS CARBON CAPTURE AND STORAGE, CAN IT CUT EMISSIONS?

The UK government on 31st July reaffirmed its support for projects to capture and store carbon dioxide emissions as part of its efforts to reach net zero goals, and said two more projects would begin negotiations to take them forward. In March, Britain had said it would invest \$ 25.7 billion over the next 20 years in the technology.

What is CCS?

There are two main types of carbon capture and storage. One is point-source carbon capture and storage (CCS) which captures CO₂ produced at the source, such as a smokestack, while direct air capture (DAC) removes carbon dioxide (CO₂) that has already been released into the atmosphere. Both the new British projects are designed to capture emissions from heavy-emitting sectors, such as oil and gas refining and steel manufacturing, and store them underground off the coast of Britain in depleted oil and gas fields.

How does it work?

First, the CO₂ has to be separated from other gases produced in industrial processes or during



Pipes run through Shell's Quest CCS facility in Alberta, Canada. Reuters

power generation. Once captured, it has to be compressed and transported to sites for storage, often via pipelines. After that, it has to be injected into rock formations underground – typically one km or more under the ground – for storage for decades.

Is the technology proven?

CCS has been in operation since the 1970s, with more than 200 million tonnes of CO₂ captured and stored deep underground globally, the Global

CCS Institute says. Many projects, however, have failed to deliver the carbon savings promised.

What role can it play?

A UN panel of scientists' report last year said CCS can help the world reach global climate targets set under the 2015 Paris Agreement on climate change, but that the focus needed to remain on preventing emissions from being emitted in the first place.

Some environmental groups, however, question how effectively CCS can curb emissions as the technology enables fossil fuel companies to operate for longer and can allow more oil and gas to be recovered from old fields.

How many facilities are there?

According to the Global CCS Institute, 61 facilities were added to the global project pipeline last year, bringing the total to more than 190. Of those, 30 were in operation, 11 were under construction and the remainder in various stages of development.

Courtesy : The Indian Express

CRYSTAL CLEAR

Dr. Abdul Ashik Khan*

This article aims to provide NEET and JEE students with a concise and comprehensive introduction to the essential concepts in chemistry, empowering them with knowledge and understanding necessary to succeed in their examination.

TAUTOMERISM (DESMOTROPISM)

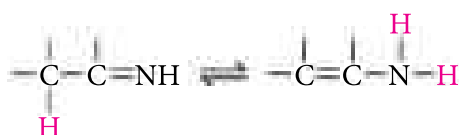
The term "tautomerism" was coined by Laar. Bond turning is referred to as Desmotropism (Desmos = Bond; Tropos = Turn). Tautomerism is a phenomena in which two structural isomers rapidly interconvert to one another by the movement of a monovalent atom (like hydrogen) with the shifting of a double bond. They continue to be in dynamic equilibrium, which varies depending on where a hydrogen atom and a double bond are located. Primarily, 1,3-hydrogen migration is involved.

Different Types of Tautomerism

- Keto-enol tautomerism :**



- Imine-enamine tautomerism :**



- Nitro-acinitro tautomerism :**



- Nitroso-isonitroso (oximino) tautomerism :**



- Lactam-lactim tautomerism :**

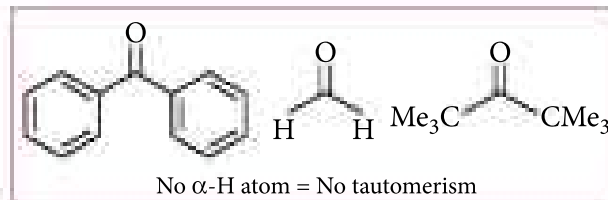


Characteristics of Tautomerism

- It takes place due to the migration of H-atoms from one polyvalent atom to another within the same molecule.
- The term "functional isomer" is also applicable to tautomers.
- Tautomers are in dynamic equilibrium with each other, meaning the conversion occurs in both directions.
- Both acids and bases can catalyse the process of tautomerism.
- The stability of tautomers is influenced by factors such as resonance effect, hydrogen bonding and steric hindrance.
- Due to the rapid shifting of H^+ ions, tautomerism is also known as cationotropy or prototropy.

Conditions for Tautomerism

- Only compounds with at least one hydrogen atom in the α -position are capable of exhibiting tautomerism.

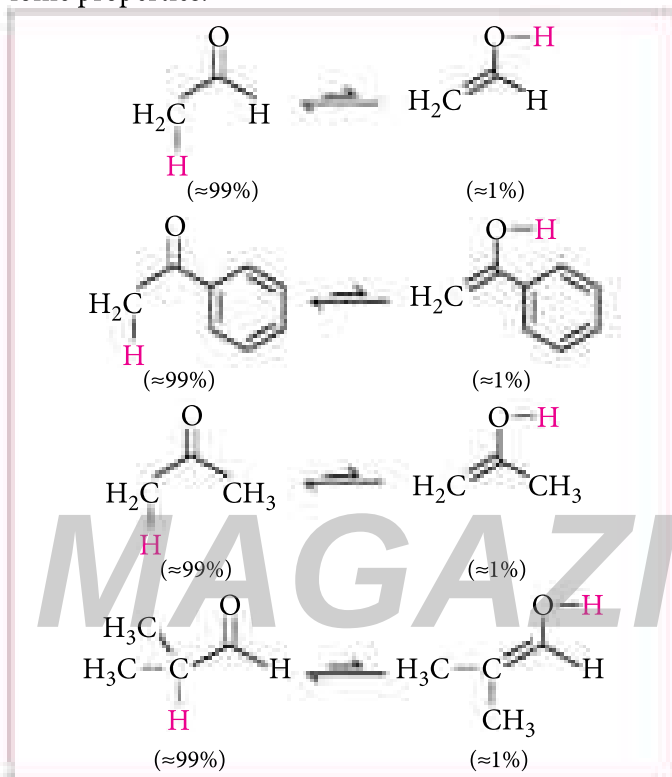


*Assistant Professor Dept. of Chemistry, Darjeeling Government College, Darjeeling, West Bengal

- The two tautomeric forms must be in a dynamic equilibrium.

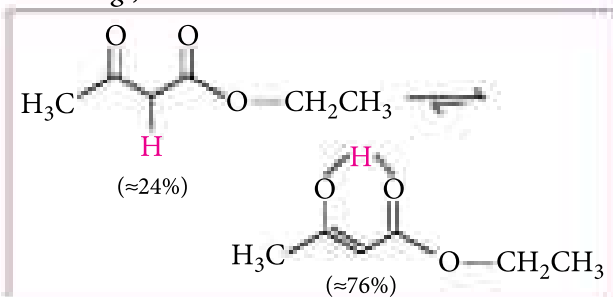
Percentage of Keto-enol content

In general, the keto form is more stable than the enol form due to the higher stability of the C=O bond than the C=C bond. Therefore, the equilibrium is shifted towards C=O bond, since it has both covalent and ionic properties.



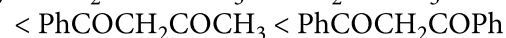
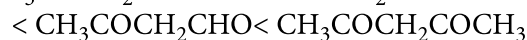
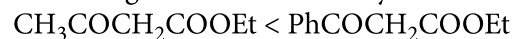
The enol form may be more stable than the comparable keto form under some unique scenarios. The greater enol concentration is caused by the following aspects :

- Intramolecular H-bonding** : Intramolecular hydrogen bonding is present in 1,3-diketo compounds, which can stabilise the structure of the enol forms to a greater extent than the keto forms. *e.g.*,

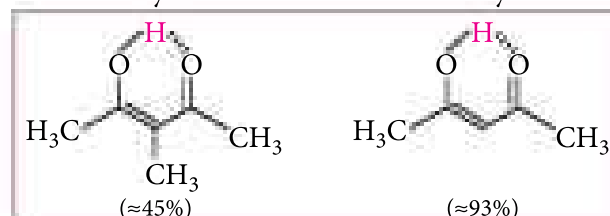


The stability of the enol formed through intramolecular hydrogen bonding (chelation) and resonance (conjugation) determines the relative quantities of the keto and enol forms.

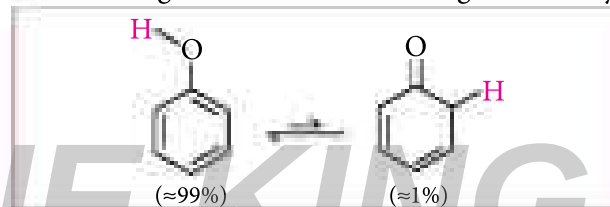
Increasing order of the stability of the enol form :



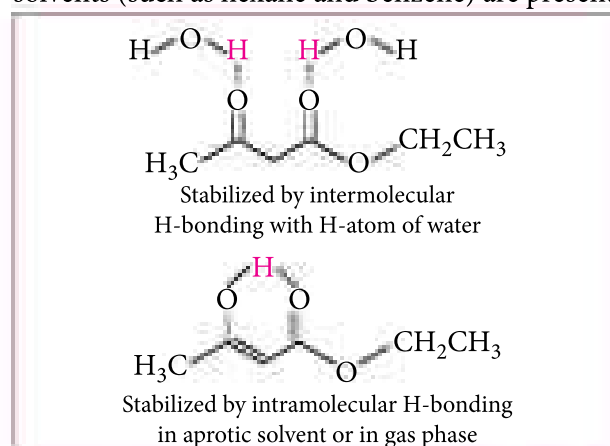
When alkyl group is substituted by the phenyl group, there is a conjugation with the phenyl group. Therefore, percentage of enol content increases. Due to the steric barrier of the α -methyl group, the enol form of α -methylacetyl acetone is considerably less stable than that of acetylacetone.



- Aromaticity** : When the enol form contains aromatic ring, the enol form has the highest stability.



- Solvent effect** : Water and methanol are examples of polar protic solvents that reduce the amount of enol while stabilising the keto form by forming H-bonds with the $-\text{C}=\text{O}$ group. The absence of solvents raises the enol content even while aprotic solvents (such as hexane and benzene) are present.

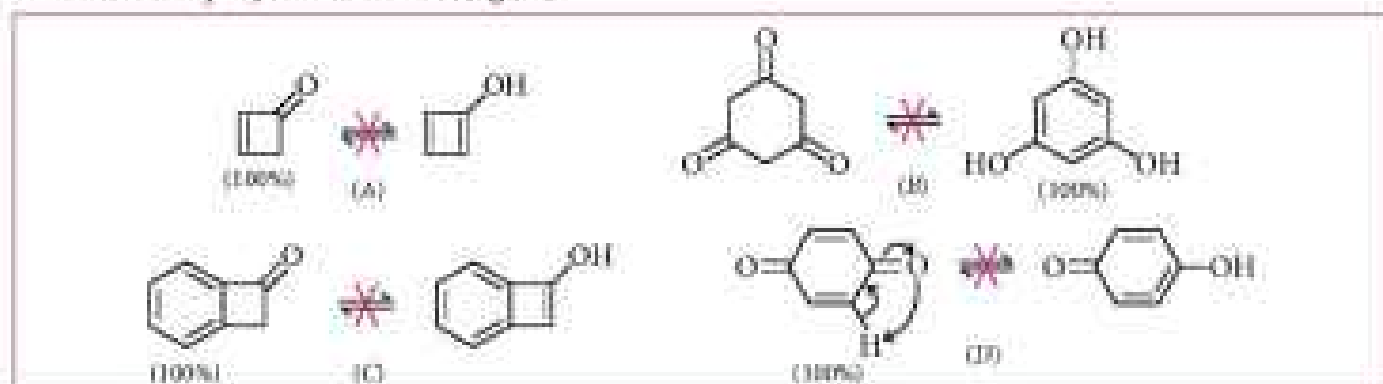


Quotable Quote

"Education is the passport to the future, for tomorrow belongs to those who prepare for it today."

Malcolm X

There are certain unusual situations when tautomerism does not occur even in the presence of an α -hydrogen atom. There are two explanations for this : (i) There is no dynamic equilibrium between the two tautomeric forms since the enol form contains anti-aromaticity (e.g., A, B, C). (ii) There is a strong C—H bond since the α -H atom attached to the sp^2 hybridised carbon (e.g., D).



Note : $H-C\equiv N$ and $H-N\equiv C$ are tautomers (also functional isomers) while $R-C\equiv N$ and $R-N\equiv C$ are only functional isomers.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I

1. MATALO
2. TERINROFENS
3. PIEREMASINITO
4. LEDUGIESCHCEE
5. CALGANATS
6. REFTIRIN
7. HINDYINRN
8. TYROSMOAF
9. CYGROSCYP
10. BUSEARNE

Column II

- (a) An iron containing protein which is important for absorption and storage of iron in the body.
- (b) The determination of molecular weight of solutes by freezing point depression method.
- (c) A group of proteins that prevent viral replication of cells.
- (d) The trivial name of cycloheptane.
- (e) A mixture of ammonium nitrate and TNT used as an explosive.
- (f) A process in which the configuration about the chiral centre of a compound, containing more than one chiral atom, is inverted to give the opposite configuration.
- (g) A branded extruded polystyrene foam used particularly in construction industry.
- (h) The process by which a substance absorbs moisture from the atmosphere until it dissolves in the absorbed water and forms a solution.
- (i) Polysaccharides which on hydrolysis give galactose.
- (j) A chemical reagent used in paper chromatography of proteins and amino acids.

Readers can send their responses at: editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

GK CORNER

Enhance Your General Knowledge with Current Updates!



PERSON IN NEWS

1 Prof. Celeste Saulo of Argentina has been appointed as the first female Secretary-General of the World Meteorological Organization (WMO). Prof. Saulo, has been Director of the National Meteorological Service of Argentina since 2014 and is currently the First Vice-President of WMO. She will take office on 1st January, 2024 and succeeds Prof. Petteri Taalas, who has completed his two-term mandate.

2 French writer Gilles Perrault, whose “Le Pull-Over Rouge” novel helped spark debate over capital punishment in France has died on 3rd August, 2023 from a cardiac arrest. Born as Jacques Peyroles, he worked for several years as a lawyer before becoming a journalist and then a novelist, writing under the pseudonym Gilles Perrault.

3 Prolific writer Salman Rushdie has been awarded the 2023 Peace Prize of the German Book Trade for “his indomitable spirit, for his affirmation of life and for enriching our world with his love of storytelling.” The announcement was made on 19th June 2023, the day when Rushdie turned 76. Rushdie will receive the award at a ceremony in Frankfurt on 22nd October, 2023. It will also be broadcasted live on German public TV.

4 Michael Rosen, a renowned writer for children and a performance poet, aged 77, has been honoured with the esteemed PEN Pinter Prize

2023. This prestigious award is given to a writer from the United Kingdom, Ireland, or the Commonwealth who fearlessly reveals truths about the realities of modern existence through their body of work.

5 N. Vittal, the key bureaucrat who helped unleash the potential of India’s software industry through helpful reforms in the 1990s has passed away on 3rd August, 2023 at the age of 85. As Chairman of the Telecom Commission, he also initiated the process of liberalisation in the telecom sector and played a major role in getting the National Telecom Policy 1994 approved. Vittal, a chemistry honours graduate of Loyola College, Chennai, was a strong advocate of ethics and a corruption-free India.

6 BRICS’ New Development Bank (NDB) has elected Thuraiya Hamid Alhashmi, Director of International Financial Relations and Organizations Department at the UAE Ministry of Finance, as a member of its Board of Directors and a Constituency Director. She was appointed following an internal voting process during NDB’s 8th Annual Meeting, held recently in Shanghai, China. Thuraiya Hamid Alhashmi will become the first Emirati and Arab woman to take responsibility as director at the New Development Bank, which was established in July 2015 by Brazil, Russia, India, China and South Africa (BRICS).

7 D.G. Rakesh Pal has been appointed as the 25th Director General of the Indian Coast Guard (ICG). He is an alumnus of the Indian Naval Academy and joined Indian Coast Guard in January 1989. He has undergone professional specialisation in Gunnery & Weapons Systems at Indian Naval School Dronacharya, Kochi, and an Electro-Optics Fire Control Solution course from the United Kingdom. The Officer holds the recognition of being the First Gunner of ICG.

8 Veteran Congress leader and former Kerala Speaker Vakkom Purushothaman, who also served as Governor of Mizoram from 2011 to 2014, has passed away on 31st July, 2023. He entered politics as a Students' Congress activist in 1946 and rose to become a state minister, Assembly Speaker, Governor of Mizoram and also Lieutenant Governor of Andaman and Nicobar Islands during his career spanning nearly seven decades.

9 Former director-in-charge of the National Institute of Technology - Tiruchi G. Kannabiran has been appointed as the new director of the National Assessment and Accreditation Council (NAAC). He was the founding director of the Indian Institute of Information Technology, Sri City, Andhra Pradesh, and worked for five years between 2018 and 2023 in that post.

10 Veteran England fast bowler Stuart Broad has

announced that the fifth Ashes Test will be his "last game of cricket", thus bringing the curtains down on an illustrious career in which he became just the second fast bowler and fourth bowler overall to take over 600 wickets in the format.

11 Union home minister Amit Shah released the book "Dr. A.P.J. Abdul Kalam : Memories Never Die" in Tamil Nadu's Rameshwaram, on 29th July, 2023. The union home minister visited Dr. A.P.J. Abdul Kalam House, Mission of Life Gallery Museum and Dr. A.P.J. Abdul Kalam National Memorial. He also visited the Vivekananda Memorial. Shri Amit Shah also offered prayers at the world famous Rameshwaram temple.

12 The President of India attended the closing ceremony of the 125th birth anniversary of Alluri Sitarama Raju in Hyderabad. Born on 4th July, 1897, Alluri Sitarama Raju is remembered for his fight against the British, in order to safeguard the interests of the tribal communities in the Eastern Ghats region (in Andhra Pradesh).

13 Swaminathan Janakiraman took over as Deputy Governor of the Reserve Bank of India (RBI) on 26th June 2023. He was appointed by the Government of India for a period of three years or until further orders. Prior to his appointment as Deputy Governor, Swaminathan was the State Bank of India's Managing Director (Corporate Banking and Subsidiaries).

Test Yourself!

- The Tamil book 'Ninaivugalukku Maranamillai', a biography of Dr. A.P.J. Abdul Kalam was written by
 - Dr. Nazema Maraikayar
 - Dr. Y.S. Rajan
 - N.C. Chhabra
 - Both (a) and (b).
- Swaminathan Janakiraman took over as Deputy Governor of the Reserve Bank of India (RBI). Prior to his appointment, Swaminathan was
 - Managing Director in State Bank of India
 - Former Secretary, Department of Revenue and Department of Economic Affairs
 - Vice-president of Asian Infrastructure Investment Bank (AIIB)
 - Chairman of the Prime Minister's Economic Advisory Council.
- Who has been elected as a member of the Board of Directors and a Constituency Director at BRICS' New Development Bank?
 - Abdulla Al Mandous
 - Gilbert F. Hounbo
 - Thuraiya Hamid Alhashmi
 - Ajay Banga
- What was the contribution of Alluri Sitaram Raju towards India during British rule?
 - He led the Rampa Rebellion against the British in which he organised the tribal people of Vishakhapatnam and East Godavari districts to revolt against the foreigners.

- (b) He led movement against caste system in South India.
 (c) He was a key coordinator in combining Non-cooperation Movement and Khilafat Movement.
 (d) He was the main leader in temple-entry movement in Kerala.
5. Who was the bowler when Yuvraj Singh hit six consecutive sixes in an over during the 2007, T20 World Cup?
 (a) Bob Willis (b) Stuart Broad
 (c) Fred Trueman (d) Sydney Barnes
6. Tiruchi G. Kannabiran has been appointed as the new director of which of the following organizations?
 (a) National Assessment and Accreditation Council
 (b) National Council of Teacher Education
 (c) Indian Institute of Education
 (d) National Institute of Educational Planning and Administration
7. Who is the author of famous novel "Le Pull-Over Rouge"?
 (a) Jules Verne (b) Gilles Perrault
 (c) George Sand (d) Victor Hugo
8. Who is the current Secretary-General of the World Meteorological Organization (WMO)?
 (a) Audrey Azoulay
 (b) Ruslan Mirzaev
 (c) Celeste Saulo
 (d) Ngozi Okonjo-Iweala
9. Vakkom B. Purushothaman, who recently passed away, was associated with which occupation?
 (a) Politician
 (b) Journalist
 (c) Scientist
 (d) Agricultural worker
10. Who has been appointed as the 25th Director General of Indian Coast Guard?
 (a) Admiral V.A. Kamath
 (b) Rajendra Singh
 (c) V.S. Pathania
 (d) Rakesh Pal

Answer Key

- (p) 10 (e) 6 (c) 8 (q) 2 (e) 9
 (q) 5 (e) 4 (c) 3 (e) 7 (p) 1

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WORD GRID

Readers are requested to send their responses of word grid. Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.



K	A	N	T	I	H	I	S	T	A	M	I	N	E	S	L	K
C	I	K	Y	O	J	L	P	D	I	W	G	J	I	M	E	P
Q	L	G	I	S	Y	E	W	H	J	F	E	L	D	Y	C	H
D	T	L	S	H	S	H	T	Q	C	K	O	E	S	O	H	E
A	K	X	O	B	K	C	E	N	Y	L	W	X	C	G	B	N
C	W	W	T	I	J	A	D	G	V	F	L	Q	T	L	E	Y
B	G	K	O	D	Q	W	D	L	C	J	R	X	T	O	J	L
H	O	D	N	C	R	F	X	I	B	N	D	R	S	B	E	K
L	R	K	I	R	J	R	B	G	R	X	Y	H	X	I	F	E
I	L	W	C	O	S	H	K	C	I	J	V	L	D	N	U	T
K	P	I	W	S	P	X	V	N	Y	O	F	V	J	D	I	O
H	Y	D	R	O	G	A	S	I	F	I	C	A	T	I	O	N
O	D	J	H	A	E	M	O	L	Y	S	I	S	D	X	W	U
P	A	W	N	S	A	X	G	M	W	J	T	O	X	P	D	R
E	V	G	N	I	T	R	A	T	I	O	N	V	N	W	C	I
R	M	S	Z	Q	F	D	H	Z	P	R	S	T	H	C	Z	A
N	X	K	R	E	P	L	I	C	A	T	I	O	N	L	K	Y

Clues

1. The term used for two solutions having the same osmotic pressure at a given temperature.
2. Rupture of cells due to inflow of solvent into it.
3. A coordination compound that stores oxygen and regulates respiration.
4. The reaction in which a haloarene reacts with a mixture of conc. HNO_3 and conc. H_2SO_4 to produce a mixture of *o*- and *p*-halonitrobenzene.
5. A disease caused due to deficiency of phenylalanine hydroxylase enzyme.
6. The process by which a single DNA molecule produces two identical copies of itself.
7. Drugs which interfere with the natural action of histamine by competing with histamine for binding sites of receptor and therefore diminish its effect.
8. The process of converting crude oil fractions to substitute natural gas.

*Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.